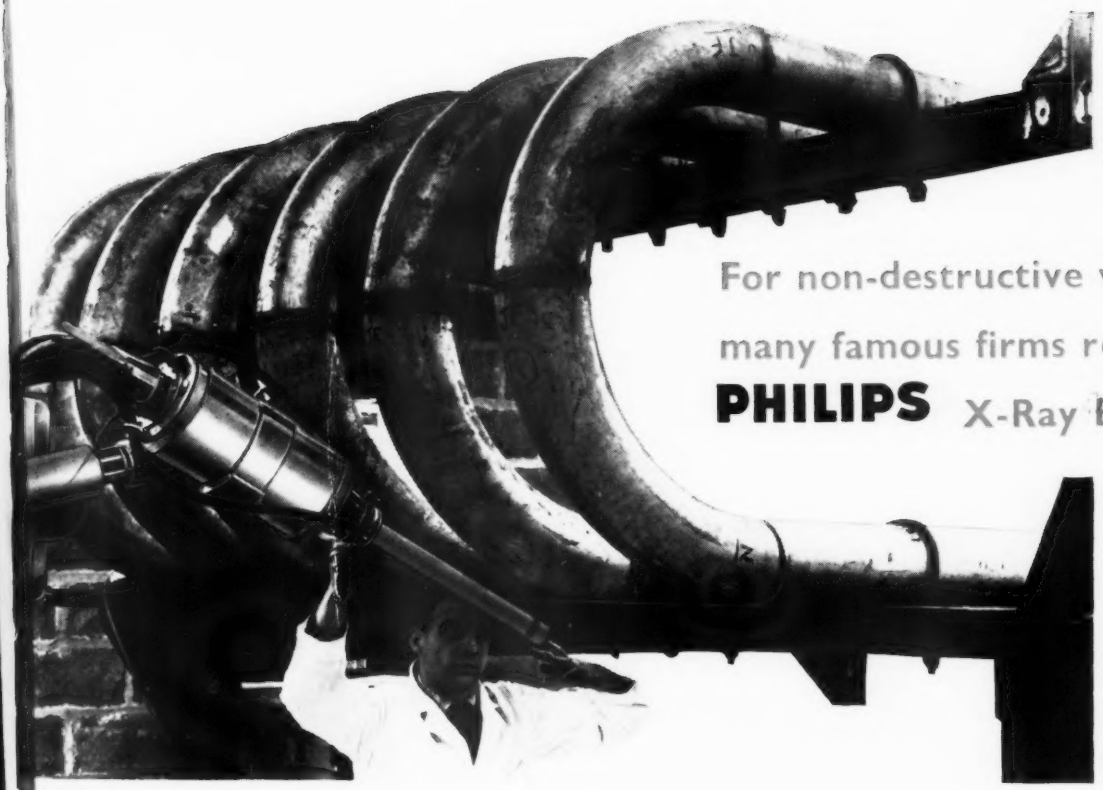
Nuclear Power

WELDING SYMPOSIUM

THE JOURNAL OF BRITISH NUCLEAR ENGINEERING

Plugs ✓



For non-destructive weld testing—
many famous firms rely on
PHILIPS X-Ray Equipment

Welded joints in this stainless steel pipework for liquid metal heat exchangers are here being inspected to extremely high standards with Philips X-Ray equipment. The heat exchangers, together with all liquid metal circuits, and principal vessels, are constructed by John Thompson Limited, Wolverhampton, for the U.K. Atomic Energy Authority's first full-scale breeder station at Dounreay, Caithness.

In the comprehensive range of X-ray equipment available from **Philips,** the needs of the nuclear power plant industry for welding inspection are most effectively catered for. For use in the shops or for work on the site there is a unit to fit the requirement. Please send us your enquiries.

PHILIPS

PHILIPS ELECTRICAL LTD

RESEARCH & CONTROL INSTRUMENTS DIVISION

Century House · Shaftesbury Avenue · London · W.C.2

Telephone: GERrard 7777

(PRC 282A)

A ROWSE MUIR PUBLICATION

MAY 1958 3/6

Tick **No 148** on reply card for further details

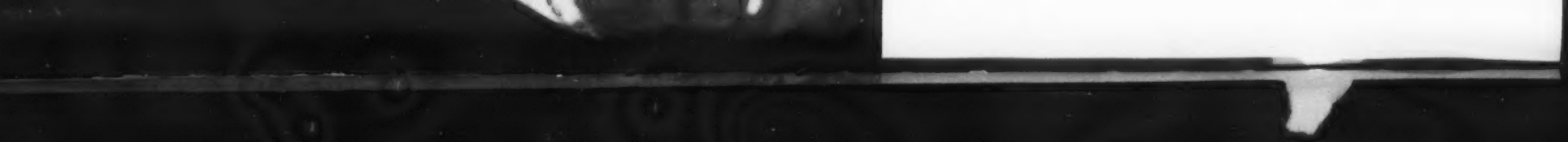
NUCLEAR POWER

Many processes involve moving or compressing gases, transferring heat from one fluid to another, or cleaning gases.

Whatever the requirements may be, Howden, specialists in the design and manufacture of the necessary equipment, are confident of their ability to meet them.

HOWDEN

JAMES HOWDEN & COMPANY LIMITED
195, SCOTLAND STREET, GLASGOW, C5, and
15, GROSVENOR PLACE, LONDON, S.W.1.



MUREX FORTREX 35A ELECTRODES

The only electrode specially designed for extra thick plate welding

The Murex "Fortrex 35A" electrode is the only electrode which has been specially designed for the welding of the extra thick plate (e.g. 3-4 inches thick and over) now being used in nuclear energy and other industrial applications. This electrode gives all the required properties throughout the whole section of the welded joint; the weld metal having particularly good impact properties—far above minimum requirements—at sub zero temperatures. The electrode also has all the advantages of the standard "Fortrex 35" type. It is an all position electrode; it is simple to use, slag removal is easy and the radiographic quality of the weld metal is sound.

"Fortrex 35A" electrodes and the technical facilities of the Murex organisation are at your service for the welding of extra thick plate.

MUREX

The world's finest welding electrodes and equipment

MUREX WELDING PROCESSES LTD., Waltham Cross, Herts

E29

Tick **No 1** on reply card for further details

Tick No 2 on reply card for further details

$$T_1 = \frac{\sum_{i=1}^{n+1} a'_i \beta'_i}{\sum_{i=1}^{n+1} \beta_i'^2}$$

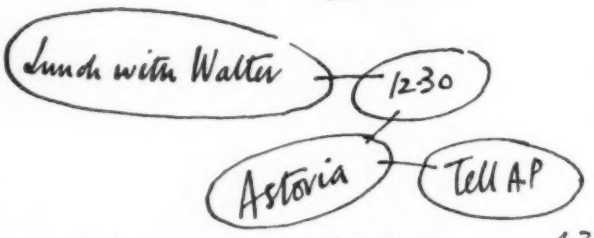
CONFERENCE NOTES

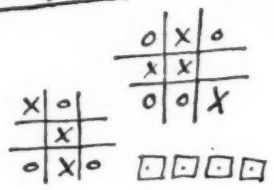
10 am : Possible energy source 100,000 curies (radio-caesium)

Heavy Water Reactor / 10-12 tons 15 MWS 66. burnup — means 67,500 tons (C)

U·K·A·E·A

Walter 26428 Ruckfield

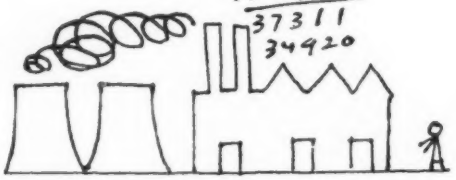


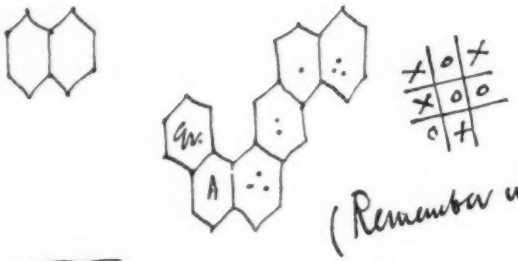


25% increased prod. Isotopes use in POLYMERISATION?

Gas/liquid cooled reactor (Gas mod.)

138
4365 | 6043618
4365
16826
13095
37311
34920

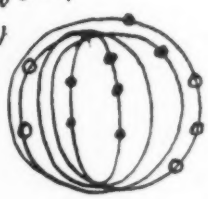




(Remember umbrella—Astoria)

Walter again—dinner?

Anticipated output 2000 MW in '65



U 235
U 238

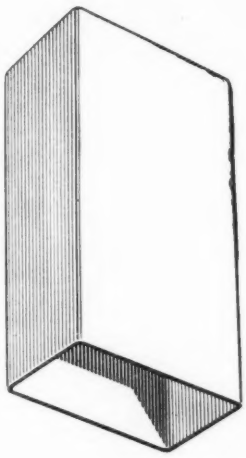
see NEWALLS re. insulation of new installation

NEWALLS INSULATION CO. LTD., *Head Office:* WASHINGTON, CO. DURHAM, ENGLAND
A member of the TURNER & NEWALL ORGANISATION
Agents and vendors in most markets abroad.

Some recent developments in manufacturing techniques and special applications of tubes in a variety of metals . . .

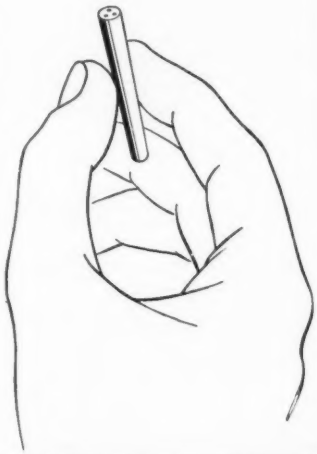
No. 2 OF A SERIES BY ACCLES & POLLOCK

Annularly convoluted seamless stainless tubing, available in a range of diameters between ½″–2″ o/d; suitable for flexible couplings, expansion joints, etc.



A rectangular wave guide tube in stainless steel, the dimensions are: .250″ x .140″ x .005/.007″ thick. Close tolerances on dimensions, with smooth internal surface conditions, are essential.

Multibore tube in austenitic stainless steel with three bores .030″ diameter, and solid nickel filler pieces. The outside diameter of the tube is .125″.



Designers have a habit of asking for the impossible, but in a surprising number of cases Accles & Pollock produce an answer that enables the production people to translate the concept on the drawing-board into a physical, functional form. Accles & Pollock welcome all such opportunities to co-operate in developing new applications in the form of tubes and tubular sections.

Accles & Pollock

Accles & Pollock Limited · Oldbury · Birmingham · A Tube Investments Company
Makers and manipulators of COLD DRAWN SEAMLESS and WELDED PRECISION TUBES in carbon and alloy steels, including stainless steel, and other metals

TSW/216

Tick **No 4** on reply card for further details

ZIRCONIUM

reactor grade zirconium
commercial grade zirconium
zirconium alloys

are available from

Jessop

VACUUM MELTING FURNACES

Hylite **TITANIUM ALLOYS**

10 Commercially pure titanium, supplied to D.T.D. specifications 5013 and 5033. Resistance to corrosion with maximum formability and weldability where strength is not critical.

15 Commercially pure titanium supplied to D.T.D. specifications 5003 and 5023.

20 5% Aluminium, 2½% Tin Alloy. An Alpha alloy of moderate strength. Being readily weldable and easily formed it is suitable for sheet metal work where higher strength than Hylite 10 is required.

30 2% Manganese, 2% Aluminium Alloy. A relatively low alloy bridging the gap between commercially pure and the high strength alloys.

40 4% Manganese, 4% Aluminium Alloy. A higher strength alloy suitable for compressor discs and blades.

45 6% Aluminium, 4% Vanadium. A high strength alloy which responds to heat treatment. Available in sheet form as well as rolled bar and forgings.

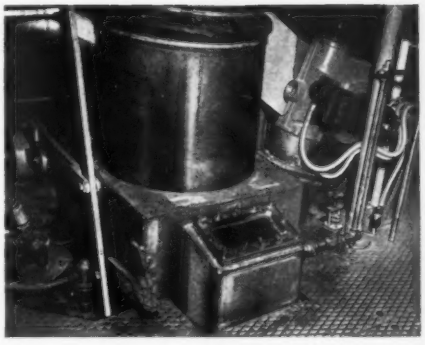
50 A complex aluminium alloy having greater strength combined with excellent creep resisting properties.

WILLIAM JESSOP & SONS LTD · BRIGHTSIDE WORKS · SHEFFIELD

A MEMBER OF THE BSA GROUP

TELEPHONE 41352 (7 LINES) · TELEGRAMS JESSOP SHEFFIELD 9

P.101



ACTIVE WASTE INCINERATORS

The H.W.P. plant at Harwell reduces all dry combustible radio-active waste to a small volume of ash for economical disposal; off-gases being scrubbed and filtered to remove active particulate matter. It is designed to minimise blow-back thus preventing operators from dust-borne radiation hazards. Waste materials are fed from a dry-box into a gravity feed hopper which has a trap to prevent blow-back into the dry-box.

THE WIDE FACILITIES AND EXPERIENCE OF HEAD WRIGHTSON PROCESSES LTD. ARE BEING CURRENTLY APPLIED TO THE DESIGN AND CONSTRUCTION OF SIX LARGE NUCLEAR RESEARCH REACTORS AND MUCH ANCILLARY EQUIPMENT—THUS PROVIDING

A COMPLETE ENGINEERING SERVICE FOR NUCLEAR DEVELOPMENT

ACTIVE MATERIAL HANDLING FLASKS

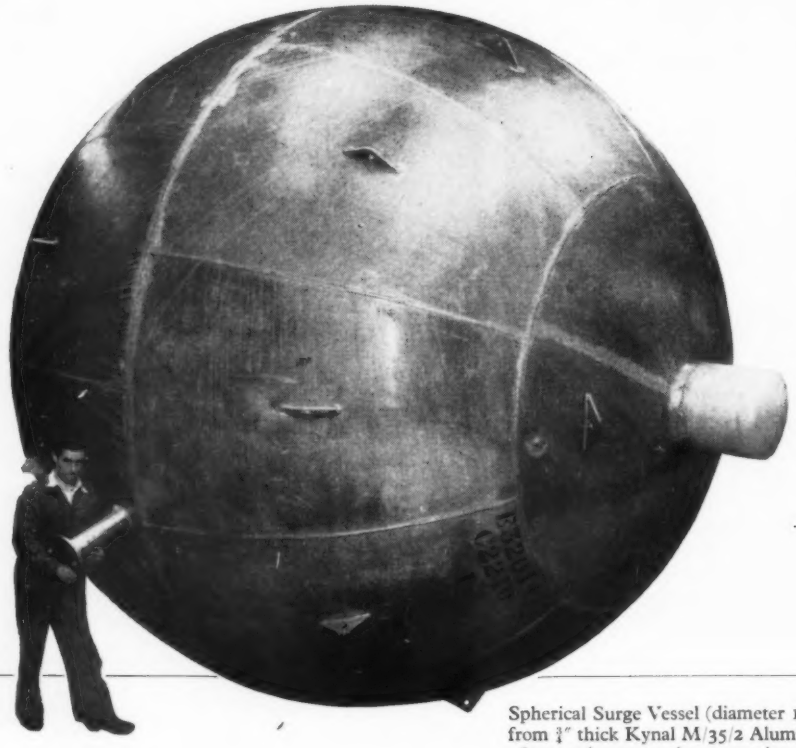
This stainless steel flask—one of many supplied for DIDO—has a 12" lead wall and is used for extracting irradiated fuel elements from the reactor and transferring them to storage. A self-contained cooling circuit is built into the flask to maintain the fuel elements at a safe temperature throughout all operations.

HEAD WRIGHTSON PROCESSES LTD

TEESDALE HOUSE 24/26 BALTIC STREET LONDON EC1

Offices at: P.O. Box 1595 **SYDNEY** · P.O. Box 1034 **JOHANNESBURG** · P.O. Box 2608 **CALCUTTA** and 603 Royal Bank Buildings **TORONTO 1**

P922



Spherical Surge Vessel (diameter 14 ft.) made from ¾" thick Kynal M/35/2 Aluminium Alloy of pressed segmental construction with dished top and bottom plates. The vessel is Argon Arc welded and vacuum tested.

Shaping the Future

Skill doesn't come easily. It has taken more than 12 years of close association with the development of Atomic Energy for Marstons to build up the specialized technical knowledge they possess in this field.
Marston Excelsior, from the start, have been among the foremost suppliers of specialized equipment to the U.K.A.E.A.—plate type fuel elements for the research reactors Dido, Lido, and Dimple; gas coolers for Calder Hall, equipment of various kinds for ancillary plants.
It is this past experience that is helping Marstons to shape the future with such precision.

MARSTON EXCELSIOR LIMITED, Fordhouses, Wolverhampton
(A subsidiary of Imperial Chemical Industries Limited)

MAR. 233

Tick **No 7** on reply card for further details

WHY MELT METALS IN A VACUUM?

The answer lies in the properties obtainable. High density, exceptional cleanness, improved mechanical properties at all temperatures, extremely low gas content — all these qualities can be obtained in high duty steels and alloys melted and cast under vacuum.

Willans are successfully producing such steels in their latest high frequency vacuum melting furnace. Its design permits absolute accuracy in final analyses by closely controlled regulation of alloying additions during melting. Observation of the melt throughout is also possible.

Willans offer facilities for either production or development work to be carried out on behalf of interested concerns and enquiries are invited from metallurgical engineers requiring metals with special high performance.

G. L. WILLAN LTD

(Approved A.I.D., D.I.Arm. A.R.B.)

Steel Manufacturers

Sussex Street, Sheffield, 4. Telephone 24211

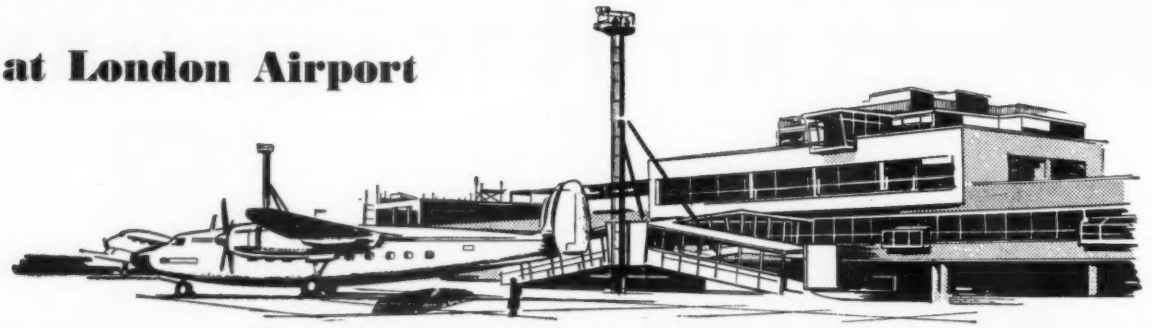
AIR-MELTED ALLOYS

Willans also produce up to 250 tons per month from air-melting electric furnaces. They manufacture all types of alloy steels under the most rigorous standards of metallurgical control. Products include melting stock, ingots, billets, bars, etc., either "off the peg" or "tailor made," in stainless steels, tool steels and special steels for nuclear energy work. Particularly attractive deliveries are offered.

OA/4452

Tick **No 8** on reply card for further details

at London Airport



CORRUSTEEL

ARMOURED CABLE

by

wandleside of wandsworth

Illustration shows "CORRUSTEEL" Armoured Cable in the Main Feeder Trunking at London Airport's new building. Electrical Contractors, The L.E.B. Contracting Section, Chelsea Manor Street, S.W.3

WANDLESIDE CABLE WORKS LTD. 106 GARRATT LANE · WANDSWORTH · LONDON S.W.18

Telephone: BATtersea 2273-4

Telegrams: "Wandleside, London"

One of **FALKS** Group.

WANDLE · BRITISH MADE · CABLE

LONDON OFFICE: 21 Fitzroy St., London, W.1. BELFAST OFFICE: Dublin Rd., Belfast, N. Ireland. BRADFORD OFFICE: 19 Union St., Bradford, Yorks

RAWLPLUG

DURIUM

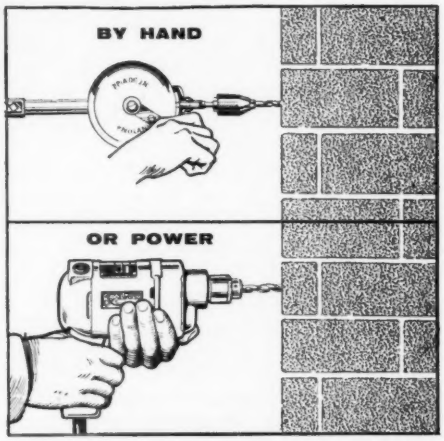
Registered Trade Mark

The world's FASTEST masonry drill

DURIUM is the drill that revolutionized masonry drilling, staggering the industrial user with its amazing speed of penetration and sharp, silent, easy-cutting *accuracy!* With its tough, almost diamond-hard Durium tip, and its patented rapid-helix flute to force out spoil and prevent clogging, the Durium Drill penetrates masonry of all kinds at a speed unequalled anywhere in the world.

and the most durable

Just as important to your costs is the extraordinary *durability* of Durium Drills. Remember that masonry is an *abrasive* material which quickly ruins ordinary drills. The astonishing *toughness* of the Durium tip, and the stronger backing of steel given it by the specially designed flute, makes Durium Drills the world's most durable masonry drill.

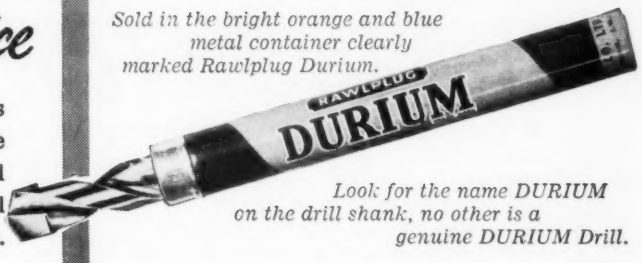


R.P.I. ELECTRIC DRILL This is the ideal power tool for use with Durium Drills. With a full load speed of 450 r.p.m. it combines high torque with a weight of less than 5 lbs.

Free resharpening service

When, at long last, your Durium Drill begins to lose its keenness, return it to us with the complimentary voucher supplied with it, and we'll re-sharpen it FREE! Write now for full details of these fastest-of-all masonry drills.

Sold in the bright orange and blue metal container clearly marked Rawlplug Durium.



Look for the name DURIUM on the drill shank, no other is a genuine DURIUM Drill.

B 589

THE RAWLPLUG COMPANY LTD., CROMWELL ROAD, LONDON, S.W.7

R. H. Campbell
SALES DIRECTOR
STOCKPORT

Bill Budd
MONTREAL

Bob Holland
BIRMINGHAM

Worldwide

You may know some of the men who sell WHARTON cranes. But you won't know the men who actually build them. And that's a pity.

We know them. We know the excellence of their work, the skill and experience which they use to such good—and lasting—effect.

Eric Ward, for instance. He began learning about WHARTON cranes when he joined our machine shop 39 years ago, to be followed 25 years later by his son Donald.

"It's the sort of place," says Eric, "where you can put your heart into the job and know that people appreciate your work. And there's always plenty of it. I've been on overtime since 1927."

It's natural that the Wards and others like them are busy. Because people DO appreciate cranes built by such craftsmen . . . WHARTON cranes.

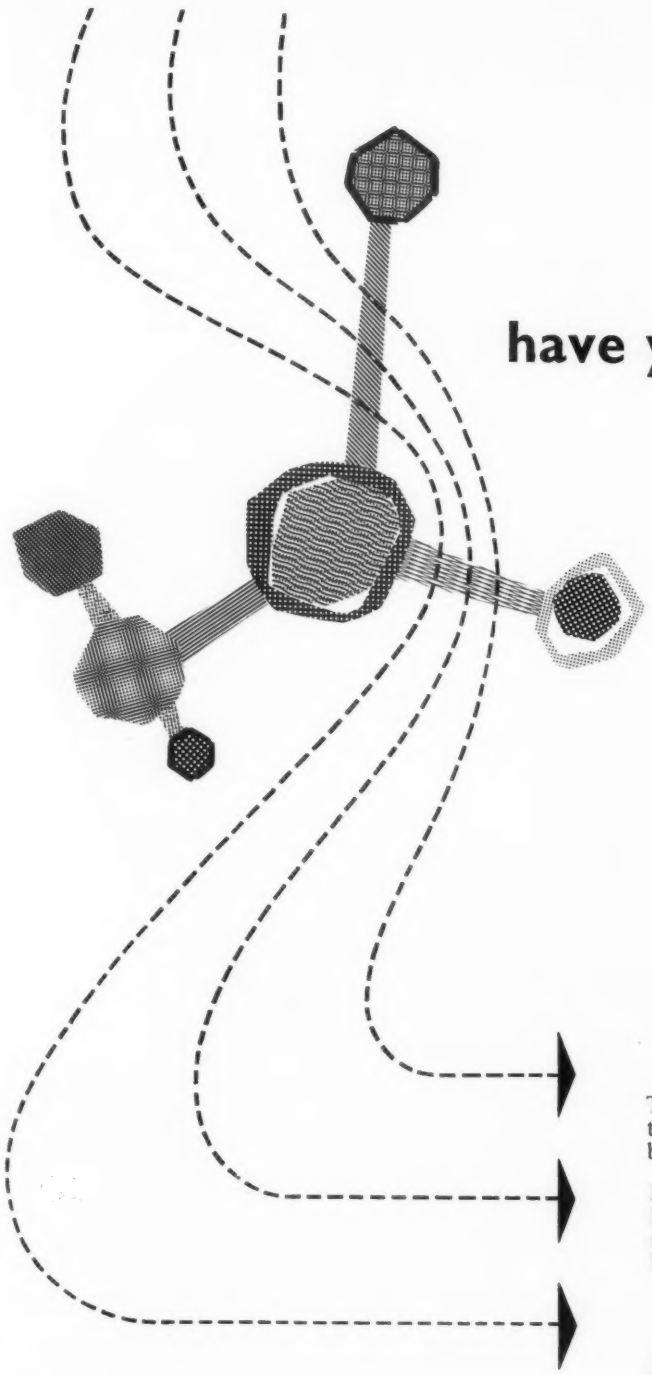
THE WHARTON CRANE & HOIST CO. LTD.

REDDISH STOCKPORT ENGLAND

Phone: Heaton Moor 2227. Grams: "Gallant, Manchester." Code: Western Union

LONDON	Lincoln House, 296-302 High Holborn W.C. 1.	Phone: Chancery 7911.	Grams: Chancery 7911.
SCOTLAND	Fisher-Baxter & Co., 140 West George Street, Glasgow C. 2.	Phone: Douglas 1061-2-3.	Grams: Fluorspar, Glasgow.
MIDLANDS	A. R. Holland & Son, 89 Cornwall Street, Birmingham 3.	Phone: Central 1457.	Grams: Central 1457, Birmingham.
SOUTH-WEST	R. C. Collins, 48 Westbourne Road, Penarth, Glamorgan.	Phone: Penarth 1527.	Grams: Penarth 1527.
NORTHERN COUNTIES	Fisher-Baxter & Co., 140 West George Street, Glasgow C. 2.	Phone: Douglas 1061-2-3.	Grams: Fluorspar, Glasgow.
NORTHERN IRELAND	General Engineering Products Ltd., 7/9 Great Patrick Street, Belfast.	Phone: Belfast 23743.	Grams: Belfast 23743.
EIRE or SOUTHERN IRELAND	Charles Nolan & Co., 2 Parnell Hill, Lower Rathmines Road, Dublin.	Phone: Dublin 93510.	Grams: Dublin 93510.
CANADA	Marshall Equipment Co. Inc., P.O. Box 38, 61 Victoria Avenue, Dorval Station, P.Q.	Phone: Melrose 1-3528.	Grams: Marquipco, Montreal.

REPRESENTED IN PRINCIPAL COUNTRIES THROUGHOUT THE WORLD.



have you a problem too?

The know-how needed to produce drop forgings to your requirements is dependent on experience backed by modern Technical resources.

If your needs are drop forgings* in special alloy, heat and creep-resisting steels or in special non-ferrous alloys, you'll solve many problems by consulting . . .

*** Drop Forgings are Stronger and Tougher**

FIRTH-DERIHON

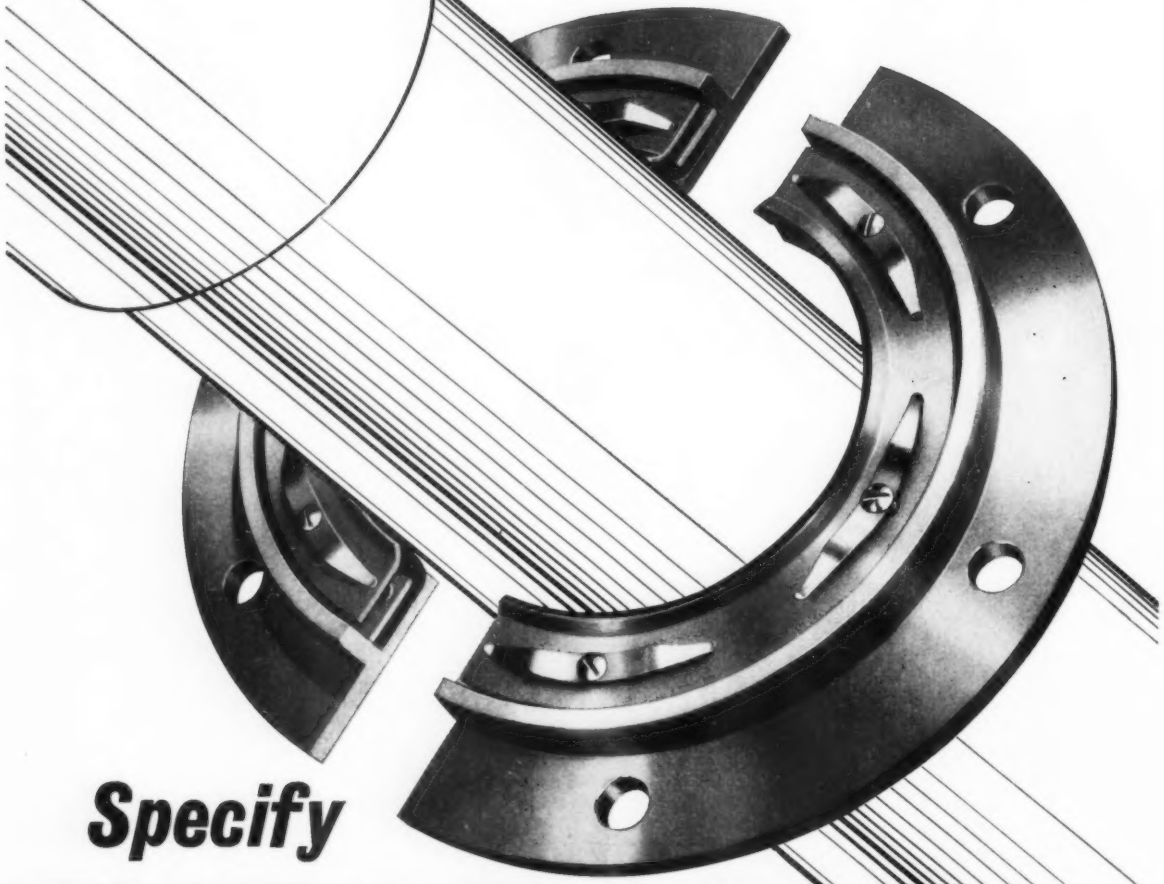
SHEFFIELD & DARLEY DALE

A 16mm. Colour Film with sound commentary, entitled "Drop Forgings in Alloy Steels," is available on request.

THE FIRTH-DERIHON STAMPINGS LIMITED, SHEFFIELD.

Tick **No 12** on reply card for further details

For ease of maintenance



Specify

WESTON

SPLIT SEALS

CHARLES WESTON & CO. LTD. Irwell Bank Works · Douglas Green · Pendleton · Salford 6

Telephone: Pendleton 2857-8-9; Telex 66-255; Birmingham Erdington 5459; London Holborn 0414; Telex 2-2682

They were vertical Glandless pumps and there's reasoning behind the choice.

The simple design having only one moving part and no close clearances ensures non-stop service and long life.

The glandless construction reduces maintenance and eliminates all leakage at the shaft.

These pumps are self-priming and can be located above liquid level.

if you want dependability—
you want LaBour

LABOUR

PUMPS

BRITISH LABOUR PUMP CO LTD
BLUNDELL ST LONDON N7 Tel NORTH 6601-5

P1058

Rocksil is *resilient* too

ROCKSIL—for either hot or cold insulation—has many important advantages to offer. Probably the most outstanding is its combination of strength with resilience—'rigid' resilience that absorbs impact and stands up well to considerable deflection of the surface it is protecting. In bonded slab form of various thicknesses and densities this makes Rocksil ideal for casing and structural insulation. It will not settle under continuous vibration even as loose infill. Rocksil is produced from natural Scottish rock and is odourless, chemically inert and sulphur-free, non-hygroscopic and rot-proof.

Rocksil Regd. ROCK WOOL INSULATION

Full information available from the manufacturers:

THE CAPE ASBESTOS COMPANY LTD.
114 & 116 Park St., London, W.1 Tel: GROsvenor 6022

and at:

Glasgow: Eagle Buildings, 217 Bothwell St., Glasgow, C.2 Tel: Central 2175

Manchester: Floor D, National Buildings, St. Mary's Parsonage, Manchester 3 Tel: Deansgate 6016-7-8

Birmingham: 11 Waterloo St., Birmingham 2 Tel: Midland 6565-6-7

Newcastle: 19 & 20 Exchange Buildings, Newcastle-upon-Tyne Tel: Newcastle 20488

a332

STANDBY GENERATING SETS

with automatic starting

FOR ATOMIC POWER STATIONS

Mirrlees

diesels

Within a few seconds of receiving the starting signal and without manual attendance, these Mirrlees oil-engine sets will carry full load, providing a reliable auxiliary and standby supply for atomic power stations and other installations where it is essential to forestall breakdowns and serious loss due to cessation of mains power supply.

The Mirrlees J and JV Types of engine cover a comprehensive series including 3, 4, 5, 6 and 8-cylinder in-line engines and 12 and 16-cylinder vee-form engines. All can be offered in naturally aspirated or turbocharged form, the latter with or without air aftercoolers. The power range extends from the 210 BHP J3 three-cylinder naturally aspirated up to the 2272 BHP JVSS16 sixteen-cylinder turbocharged engine with air aftercooler.

MIRRLEES, BICKERTON AND DAY LIMITED

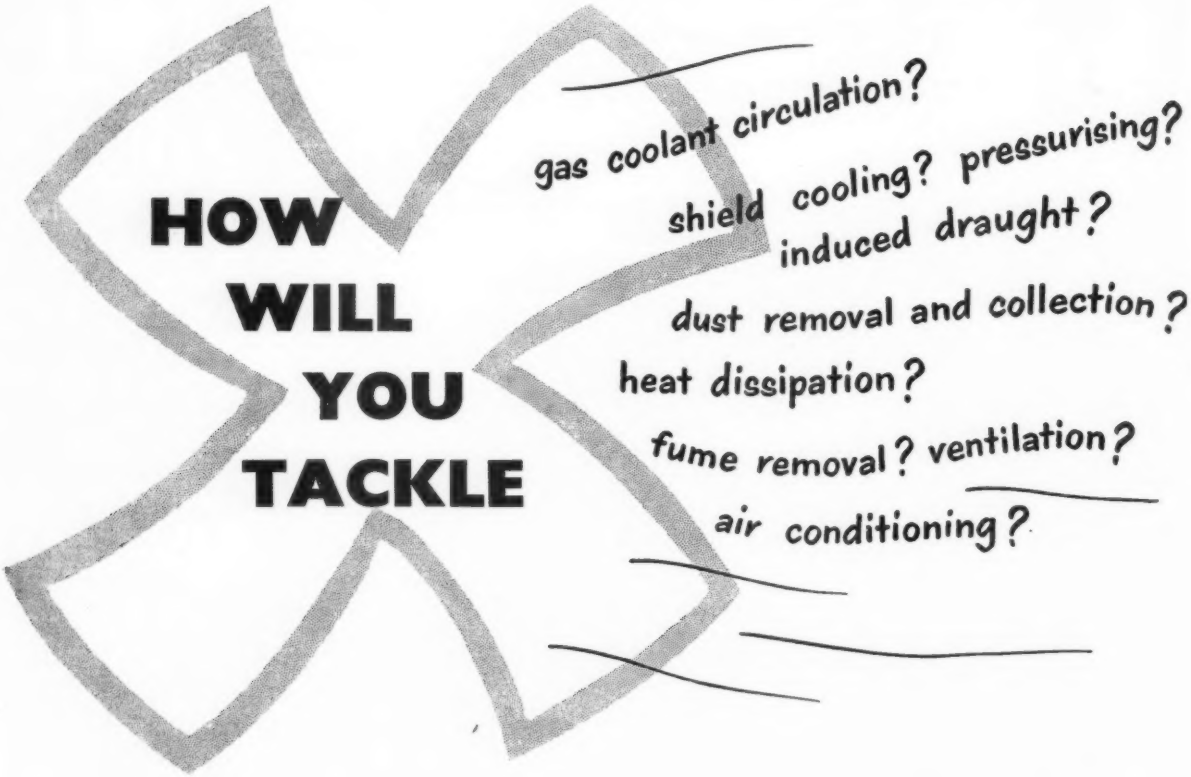
HAZEL GROVE · STOCKPORT · CHESHIRE

A member of the HAWKER SIDDELEY Group

Tick **No 15** on reply card for further details

Telephone: Stepping Hill 3841 (14 lines) *Telegrams:* "Mirrlees Telex, Manchester"

IE12



Keith Blackman can supply every type of special air or gas handling equipment you are likely to need. Made of appropriate materials and ruggedly constructed, it will deal with high pressures, high temperatures, large volumes and any other arduous conditions. 74 years' experience has made us specialists in the unusual, and we believe in designing 'the fan for the job'. Yet your more conventional requirements can be met by our very comprehensive stock of standard equipment.

Every fan, special or standard, undergoes exacting running tests for maximum reliability; we know how the breakdown of one unit can start a chain of other stoppages, resulting in costly delay.

When only the best is good enough, take it from us

Tornado

FAN ENGINEERING EQUIPMENT

KEITH BLACKMAN LIMITED · LONDON AND ARBROATH
HEAD OFFICE: MILL MEAD ROAD, LONDON, N.17

Suppliers of fans and blowers to U.K.A.E.A. plants at Aldermaston, Capenhurst, Dounreay, Foulness, Harwell, Risley, Springfields and Windscale.

TA 10484/785

Tick No 17 on reply card for further details

G.E.C. Nuclear Research and Development—No.4

Uranium-to-can Heat Transfer

In a nuclear power reactor metallurgical considerations impose a limit on the temperatures that can be allowed in the uranium fuel rods. At the same time it is essential, for efficient heat transfer to the gas, that the can should be as hot as possible. It is thus necessary to determine the temperature drop that will occur between the centre and the surface of a fuel element.

The temperature drop between the centre and surface of the uranium is calculable by straightforward methods, but at the uranium/can interface a further drop takes place since the metal faces are not perfectly smooth. This can be determined only by experiment.

At the Erith laboratories of the G.E.C. the apparatus pictured above is used to measure the temperature drop as a function of surface temperature, for a variety of uranium surface finishes and with different gas fillings in the cans. One end of a cylindrical rod of canning material is heated, and heat flows along the cylinder, through a uranium test piece and into a second length of canning material, while thermocouples measure the temperature distribution along the heat path.

The results obtained facilitate the design of more efficient fuel elements and also make it possible to predict the temperatures that will prevail in the individual components under all possible conditions.

G.E.C.

Atomic Energy Division

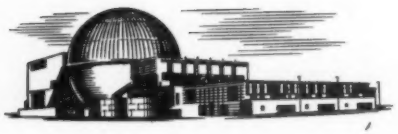
THE GENERAL ELECTRIC CO. LTD · MAGNET HOUSE · KINGSWAY · LONDON · W.C.2.

A229

Tick **No 18** on reply card for further details

BY APPOINTMENT TO HER MAJESTY THE QUEEN
Suppliers of Fire Extinguishers *The Pyrene Company Limited*

facing new fire problems in the sphere of nuclear power



The Pyrene Company, with its unrivalled facilities for research, keeps ahead of changing industrial techniques, and is constantly developing the means to overcome the new fire risks they involve. As makers of the world's most comprehensive range of fire-fighting equipment, The Pyrene Company can give you invaluable and impartial advice on any fire protection problem—it is yours for the asking.

We are proud to have given advice on fire protection—and supplied major fire-fighting equipment—for most British atomic centres already constructed. Consult Pyrene Fire Engineers and ensure maximum protection for invaluable plant, and human lives too.

Pyrene TRADE MARK FIRE APPLIANCES

protect

ALDERMASTON
CALDER HALL
CAPENHURST
DOUNREAY · FOULNESS
HARWELL · SPRINGFIELD
WINDSCALE

Pyrene TRADE MARK FIRE FIGHTING EQUIPMENT

THE PYRENE COMPANY LIMITED

(Dept. NP 5) 9 GROSVENOR GARDENS · LONDON S.W.1 *Tel:* VICtoria 3401

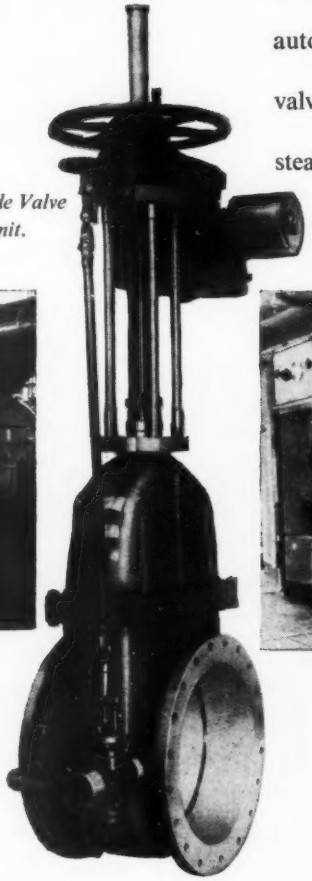
Head Office & Works: GREAT WEST ROAD · BRENTFORD · MIDDX

Canadian Plant: TORONTO

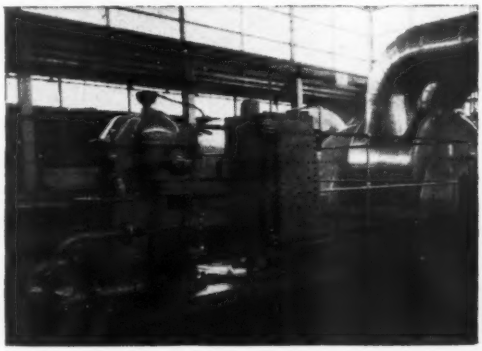
HOPKINSONS' equipment at CALDER HALL

20 in. bore Deadweight Relief Valve. The largest Safety or Relief Valve ever built by Hopkinsons.

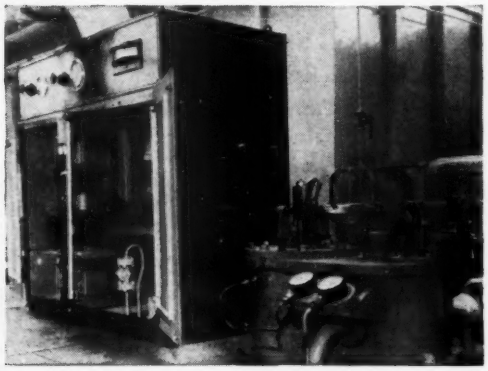
For the power station of the United Kingdom Atomic Energy Authority at Calder Hall, our valves and fittings have been supplied in very large quantities including valves ranging from ¾ in. to 28 in. bore, electrically-operated parallel-slide valves, desuperheating equipment, relief valves, combined stop and isolating valves, automatic exhaust valves, "Uniflow" valves, non-return valves, "Nolos" steam traps, centrifugal oil purifiers etc.



26 in. bore Parallel-slide Valve with electric control unit.



Centrifugal Purifier for continuous purification of turbine lubricating oil. Photograph by courtesy of the United Kingdom Atomic Energy Authority.



Desuperheater control cubicle, with mechanically-operated 8-way control valve and electrically-operated 2-way control valve. Photograph by courtesy of the United Kingdom Atomic Energy Authority.

HOPKINSONS LIMITED • HUDDERSFIELD

LONDON OFFICE: 34 NORFOLK STREET • STRAND • W.C.2

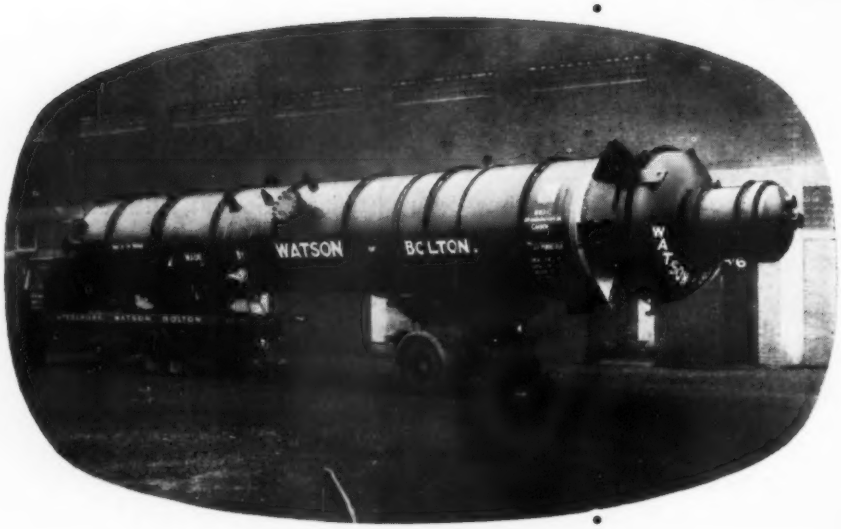
HV 90
A19

Tick **No 20** on reply card for further details

Pressure Vessels

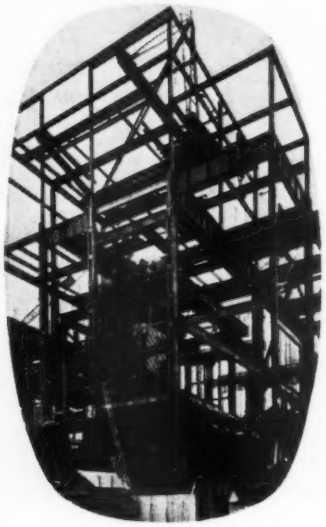
Welding ▲

Welded Vessel 63 ft. long 15 ft. dia. Transported to Coryton Refinery, Kent.



Structures

Steelwork to Extension at Worcester Power Station ▼



We specialise in pressure vessels as seen in this vessel for Shell Petroleum Co., Ltd. 55 ft. long: 6′ 6″ dia. To ASME Code

STEELWORK

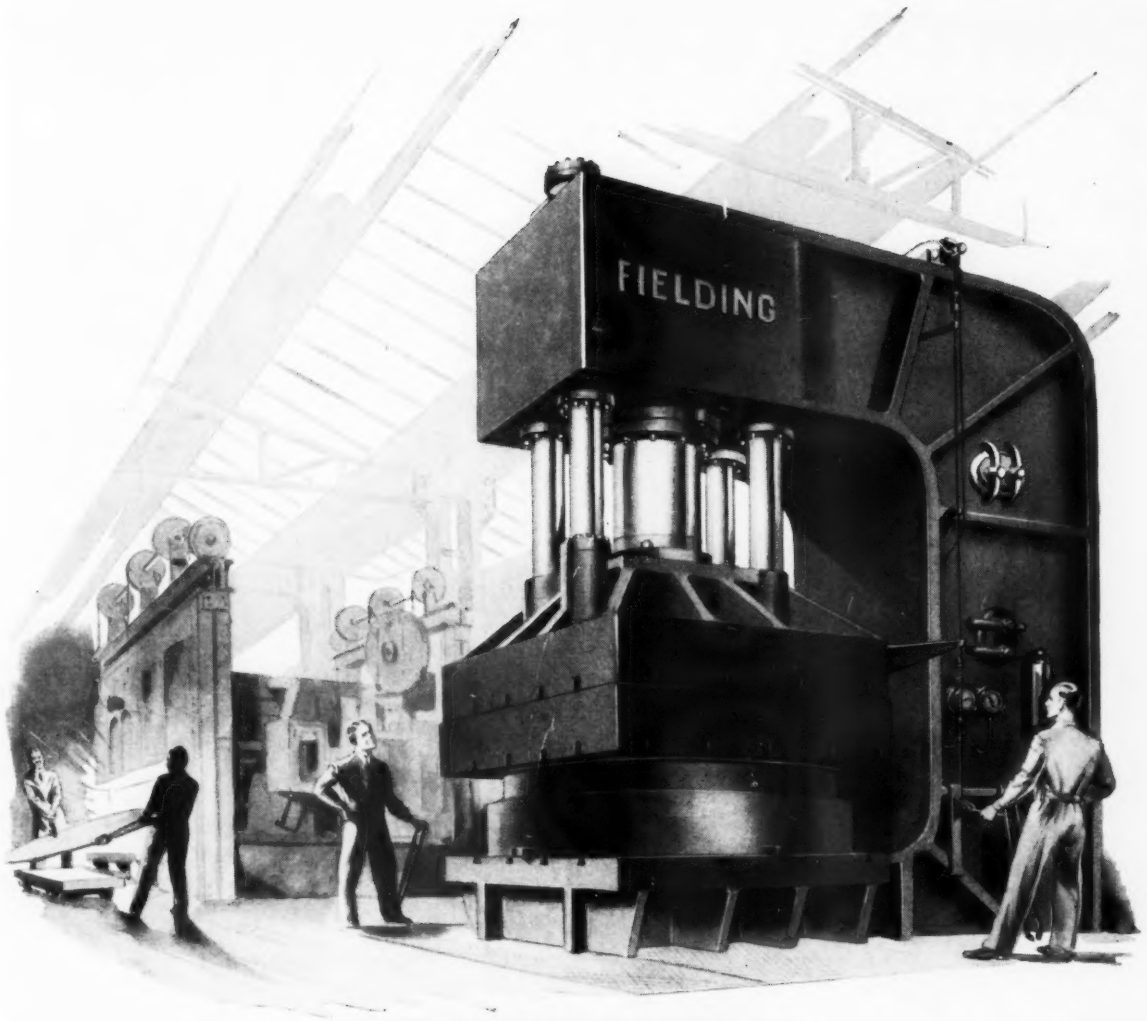
WATSON

BOLTON

Robert Watson & Co.
(CONSTRUCTIONAL ENGINEERS)
Limited, Bolton
Telephone: Bolton 5125 (7 lines)
Telegrams: Watson, Telex, Bolton
and at London
Telephone: Belgravia 3785-7
and Bristol
Telephone: Filton 2361

Inspection facilities include Laboratory equipped with up-to-date Testing and Radiography machines

Tick **No 21** on reply card for further details



FIELDING
OPEN GAP PRESSES

A wide range of "Fielding" Hydraulic Open Gap Presses is available, covering a variety of applications. These Presses are supplied complete with self-contained pumping equipment, or alternatively to operate from an Accumulator System . . . . Your enquiries will receive our careful and prompt attention.

FIELDING & PLATT LTD
ENGINEERS ATLAS WORKS
GLOUCESTER • ENGLAND

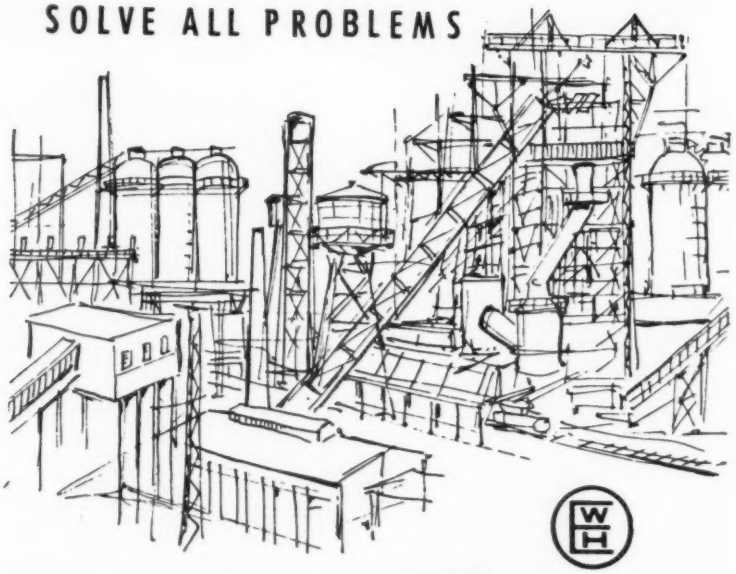
Tick **No 22** on reply card for further details

THE WORLD-WIDE-FAMOUS

ERHARD
VALVES

known for their Design, Precision and Quality for more than 80 years.

SOLVE ALL PROBLEMS



JOHANNES ERHARD H. WALDENMAIER ERBEN
Süddeutsche Armaturenfabrik, Heidenheim / Brenz · Germany
Telephone 3881 Cable · Erhardarmaturen

For all information write to:

The Sole Agents for the United Kingdom

A.K. STARCK'S CO. LTD. 22, Chancery Lane London W.C. 2
Telephone Holborn 2966 Cable: Akstar London

Pattern of protection

The persistent upward trend of maintenance costs is a bugbear that can throw any budget out of gear and the cost of genuine red lead is one of the contributory factors. Now leading authorities specify "Superlative" Metal Primer to offset much of this cost. "Superlative" ensures complete protection for all ferrous metals. And as well as saving in initial material costs it has the advantages of easier, quicker application than red lead and greater coverage. Resultant reduced labour charges emphasize further the lower maintenance costs effected by "Superlative" Metal Primer.

'Superlative' Metal Primer prevents corrosion economically. *Our Techniservice will gladly answer all enquiries*

BRITISH PAINTS LIMITED

Portland Road, Newcastle upon Tyne, 2.
Crewe House, Curzon St., London, W.1.

Sydney, Adelaide, Toronto, Durban, Cape Town, Calcutta, Trinidad, New York, Arklow

Our world-wide service is at your disposal for the asking

BPL/IM11

production engineers

fully equipped for the manufacture of

graphite components.

fabricators of

special equipment *for the*

ATOMIC ENERGY AUTHORITY

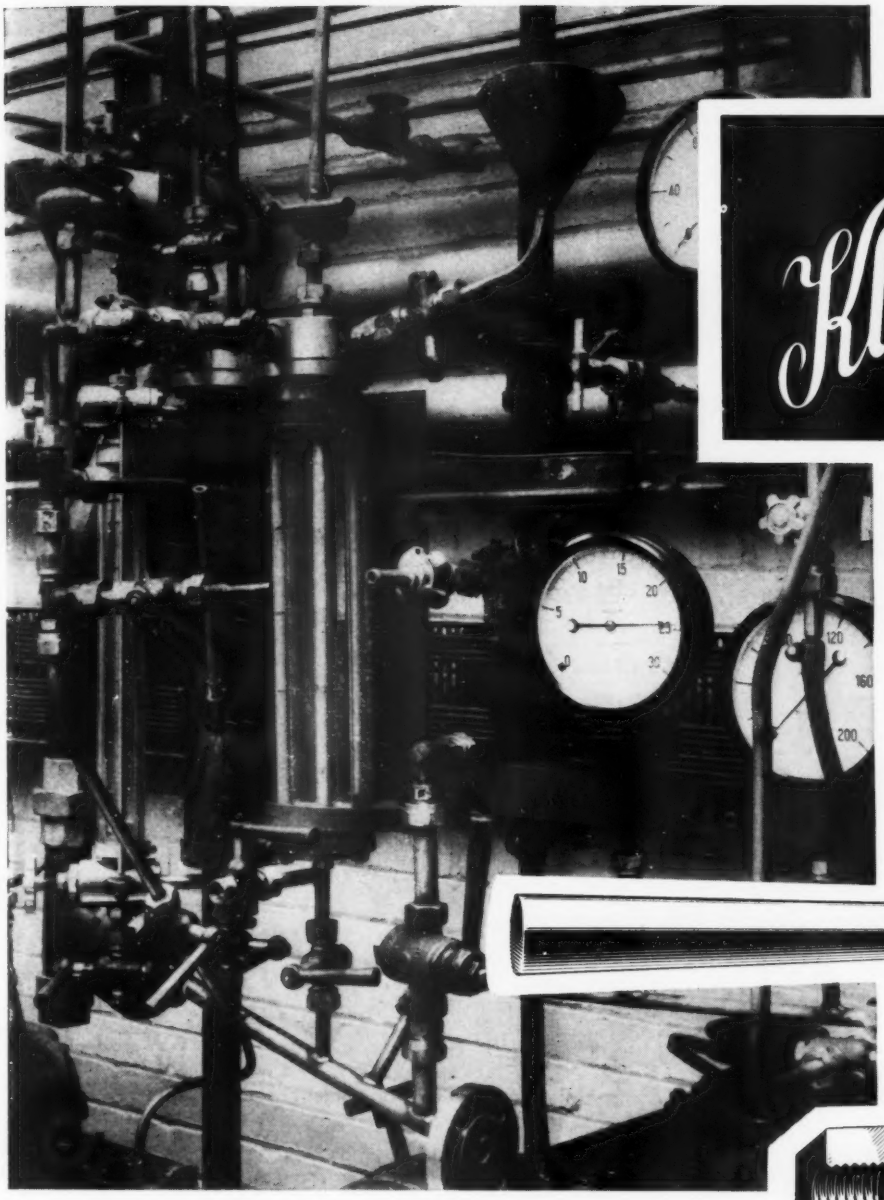
If YOU have a special problem, apply to:

Registered Office:
29 ST. JAMES'S ST.,
LONDON, S.W.1.
Tel.: Whitehall 6478

GRAVINER MFG. CO., LTD.,
Fareham Road, Gosport, Hants.
Tel.: Gosport 89175

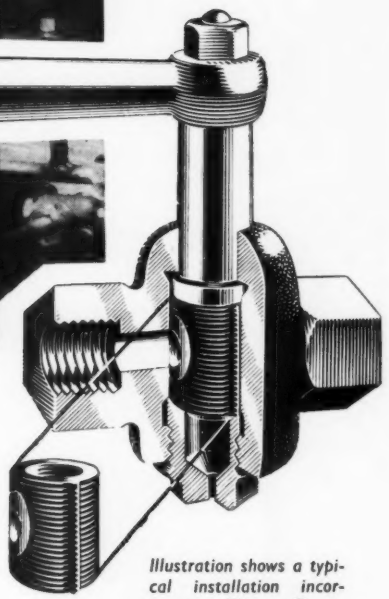
Aircraft Division:
POYLE MILL WORKS,
COLNBROOK, BUCKS.
Tel.: Colnbrook 2345

also specialists in Industrial Explosion Protection, Airborne Fire Protection Equipment, Thermostats and Overheat Switches.



Klinger

SLEEVE-PACKED COCKS



In the last quarter of a century Klinger Sleeve-Packed Cocks have steadily replaced the old-fashioned asbestos-packed cocks with their limitations of working pressure, difficulty of repacking and tendency to jam. They are available in a wide range of designs and sizes for all purposes and pressures, and with the following advantages:

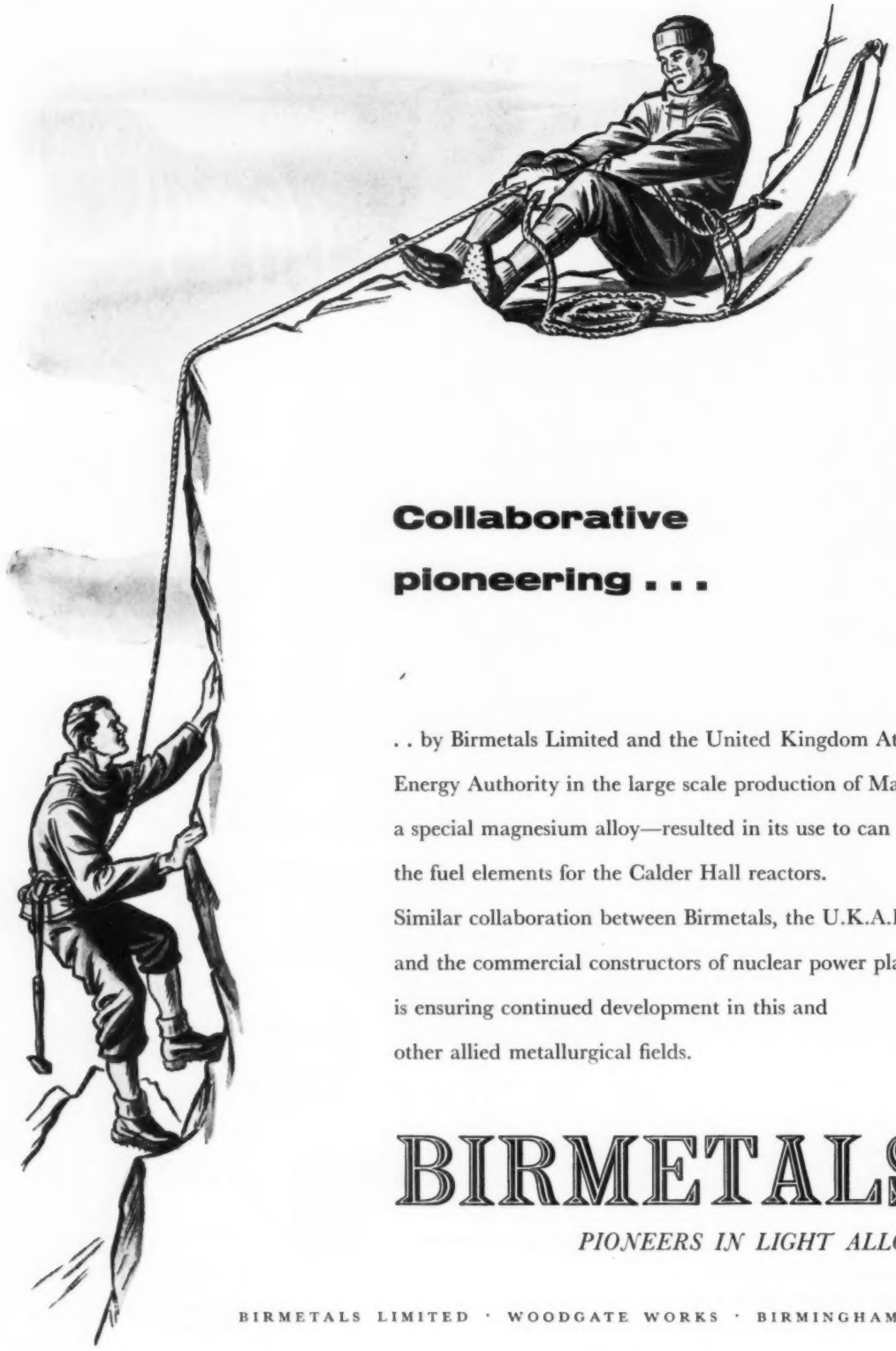
- **Renewable "Klingerit" packing sleeve.**
- **Re-tightening during use.**
- **Parallel-ground non-jam plug.**
- **Unobstructed straight-thru full-bore passage.**

Illustration shows a typical installation incorporating Klinger Sleeve-Packed Cocks, at a famous research establishment.

RICHARD KLINGER LIMITED

KLINGERIT WORKS · SIDCUP · KENT *Tel: Foots Cray 7777*

C13/58/C



Collaborative pioneering . . .

. . by Birmetals Limited and the United Kingdom Atomic Energy Authority in the large scale production of Magnox—a special magnesium alloy—resulted in its use to can the fuel elements for the Calder Hall reactors. Similar collaboration between Birmetals, the U.K.A.E.A. and the commercial constructors of nuclear power plants is ensuring continued development in this and other allied metallurgical fields.

BIRMETALS

PIONEERS IN LIGHT ALLOYS

BIRMETALS LIMITED · WOODGATE WORKS · BIRMINGHAM 32

BM108

TURBINE-GENERATORS and ancillary apparatus.
GAS TURBINES for application on land and sea.

MOTORS for every industrial application.
CONTROL GEAR for all motor drives.

TRACTION equipments for electric and diesel-electric locomotives and trains, and for trolley-buses. Railway Signal Equipment.

TRANSFORMERS
SWITCHGEAR
INSTRUMENTS
METERS & RELAYS

TESTING EQUIPMENT
ELECTRONIC CONTROL

WHATEVER THE INDUSTRY, you will find that the products of this company are contributing to the efficiency and smooth running of the electrical plant.

A few of the more important manufactures of the Metropolitan-Vickers organisation are listed in the panels, and the company will be glad to give you full details and descriptive literature dealing with the wide diversity of electrical equipment manufactured for every industrial and scientific application.

WELDING EQUIPMENT AND ELECTRODES

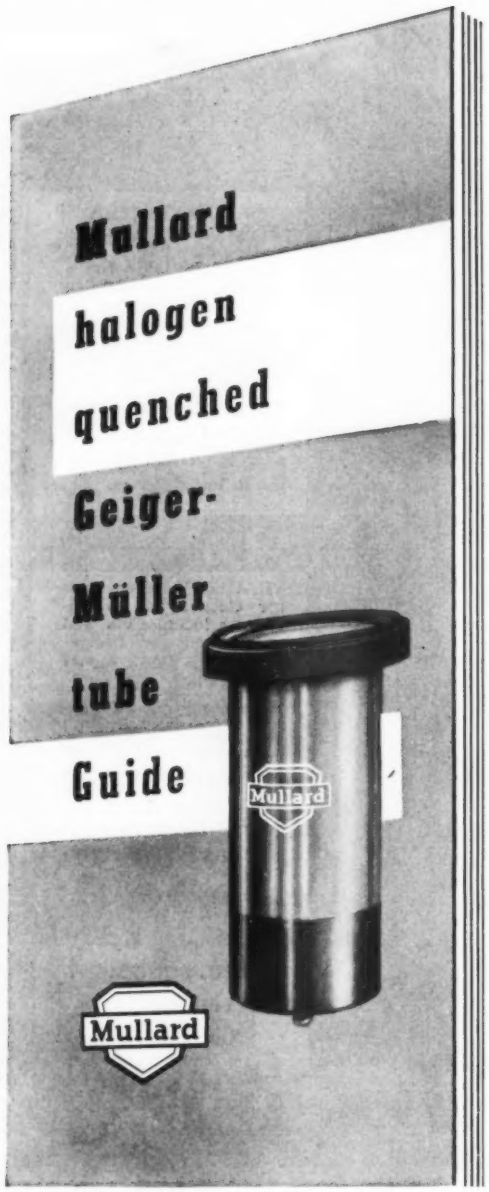
X-RAY EQUIPMENT for all industrial applications

METROPOLITAN-VICKERS
ELECTRICAL CO LTD TRAFFORD PARK MANCHESTER 17

An A.E.I. Company

LEADING ELECTRICAL PROGRESS

A/A610



Do you use Geiger Müller Tubes?

To meet an ever growing demand in the fields of medicine research and industry, Mullard have developed a comprehensive range of Geiger Müller Tubes that includes types for almost every application.

Then get your copy of this valuable tube guide

This guide has been prepared to assist users of Geiger Müller Tubes in selecting the right tube from the Mullard range for optimum performance in any given application. It is a valuable source of reference. Make sure of your copy by writing to the address below now.

It will help you choose the best tube for the job

To Mullard Limited, X-ray Division, New Road, Mitcham Junction, Surrey.
Please supply us with.....copies of your Geiger Müller Tube Guide.

NAME .....

ADDRESS .....

.....

..... N.P.

Mullard

X-RAY DIVISION

MULLARD LTD., X-RAY DIVISION,
NEW ROAD, MITCHAM JUNCTION, SURREY
Telephone: Mitcham 3471

MXR 500

Tick **No 29** on reply card for further details

FOR

INSTRUMENTATION

AND PROCESS

CONTROL

consult

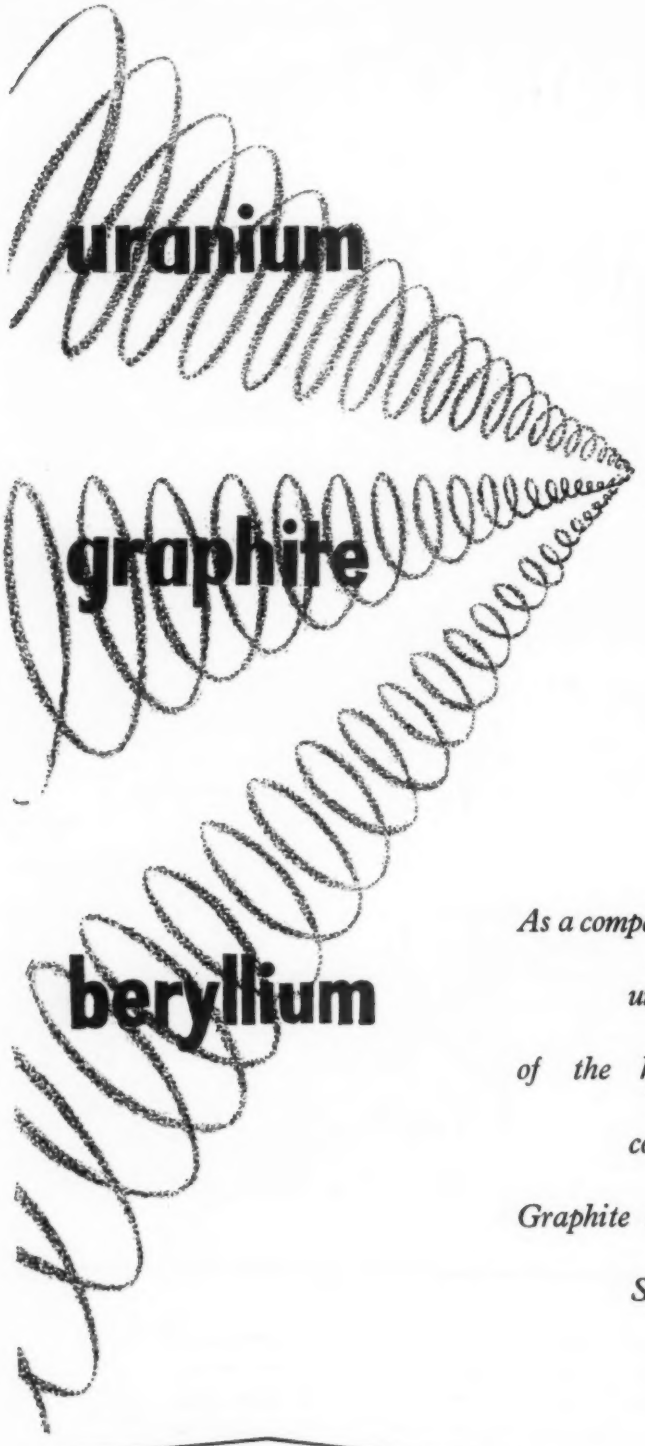
EVERSHED

The Pioneers of Electronic Process Control

The salient points about the Evershed system of automatic electronic process control are its accuracy, flexibility, simplicity, and ease of maintenance. It has been successfully applied to the Petroleum, Chemical, Iron and Steel, Steam Generation (Conventional and Nuclear), Cement, Sugar Refinery and Food Processing Industries.

EVERSHED & VIGNOLES LIMITED · CHISWICK · LONDON W.4
EVERSHED & VIGNOLES (CANADA) LIMITED · TORONTO · CANADA
EVERSHED ENRAF · DELFT · HOLLAND

Tick **No 30** on reply card for further details



high efficiency DUST COLLECTION installations

As a company, we can already claim unique experience in the design of the highly specialised dust collection installations in Uranium, Graphite and Beryllium Machine Shops.

mancuna **ENGINEERING LTD., DENTON, MANCHESTER**

Phone : DENTON 3965 (5 lines)

59 VICTORIA ROAD, SURBITON, SURREY. *Phone : Elmbridge 9793*

HEATING · VENTILATING · FILTRATION · AIR CONDITIONING · HUMIDITY CONTROL · ETC.

Power to feed the multitudes

How can we grow food for an increasing world population? Not by the primitive agricultural methods of the past. To improve our husbandry, we must have power—physical energy, plentiful and cheap.

Nuclear fission is one source of such power. Already, Britain has shown the world how to tame the power of the atom for peaceful ends.

The AEI-John Thompson Company is building one of Britain's first nuclear power stations, at Berkeley in Gloucestershire. Into that enterprise has gone the skill of such mighty firms as BTH, Metropolitan-Vickers and John Thompson. Now, this great consortium of talents is ready to serve the multitudes of the world.

A·E·I

JOHN THOMPSON

Tick **No 32** on reply card for further details

to strain,

or to filter

diesel **FUEL** or **PETROL**...

lubricating,

edible, or cutting **OILS**...

AIR... LIQUIDS... POWDERS... DUSTS... GASES

interpose an INTERMIT

filter, strainer, or gauze...

INTERMIT limited

specialists in the design and production of filters, strainers, and ventilators to specification or by collaborative research and development.

Enquiries to:
INTERMIT LIMITED · BRADFORD STREET · BIRMINGHAM 5
Phone: Midland 7961

Member of the BIRFIELD Group

BIRFIELD INDUSTRIES LIMITED · STRATFORD HOUSE · LONDON · W1

SERVICE DE RENSEIGNEMENTS POUR NOS LECTEURS

Il est souvent difficile au client publicitaire d'indiquer dans un espace restreint tous les détails de ses produits. Dans le cas où vous désireriez de plus amples renseignements à ce sujet, veuillez pointer le numéro approprié sur la carte ci-contre et envoyer cette dernière à NUCLEAR POWER.

AUSKUNFTSDIENST FÜR LESER

Es ist oft schwierig für Inserenten alle technischen Einzelheiten über ihre Produkte in einem begrenzten Platz zu bringen. Sollten Sie noch weitere Auskünfte wünschen, streichen Sie einfach die bestimmten Nummern auf der nebenstehenden Karte an, und senden Sie sie an NUCLEAR POWER.

SERVIZIO D'INFORMAZIONI PER I NOSTRI LETTORI

E' talvolta difficile all'inserzionista di indicare in uno spazio ristretto tutti i particolari dei suoi prodotti. Qualora desideraste ricevere più ampie informazioni a questo riguardo, favorite segnare il numero appropriato sul cartellino qui accanto ed inviare quest'ultimo a NUCLEAR POWER.

SERVICIO DE INFORMACIÓN PARA EL LECTOR

Se hace a menudo difícil para los anunciantes dar en un espacio limitado todos los detalles técnicos sobre sus productos. Si desea ulterior información, marque los números apropiados en la tarjeta opuesta y mándela a NUCLEAR POWER.

Информация для читателей

Часто бывает трудно рекламирующим лицам давать все технические подробности своей продукции в рекламе. Если Вам понадобятся добавочные сведения, то просто отметьте соответствующие номера на карточке на противоположной стороне и отправьте в NUCLEAR POWER.

讀者詢問服務

在廣告上以有限的地方來解釋一些專门技術 及它們的効果 的確是有受限制的困难若讀者欲要知道一些詳細的情形就請將对頁的表格 取一號下來將閱下有疑问的項目 问笔勾一那号碼子能工程总即可.

読者サービス

廣告紙面の関係上製品の技術的細目は掲載しきれませんので詳しくは裏のカードの通當なナンバーに印をつけて原まが完投面して下さればお答へします.

Nuclear Power
THE JOURNAL OF BRITISH NUCLEAR ENGINEERING

1	26	51	76	101	126	151
2	27	52	77	102	127	152
3	28	53	78	103	128	153
4	29	54	79	104	129	154
5	30	55	80	105	130	155
6	31	56	81	106	131	156
7	32	57	82	107	132	157
8	33	58	83	108	133	158
9	34	59	84	109	134	159
10	35	60	85	110	135	160
11	36	61	86	111	136	161
12	37	62	87	112	137	162
13	38	63	88	113	138	163
14	39	64	89	114	139	164
15	40	65	90	115	140	165
16	41	66	91	116	141	166
17	42	67	92	117	142	167
18	43	68	93	118	143	168
19	44	69	94	119	144	169
20	45	70	95	120	145	170
21	46	71	96	121	146	171
22	47	72	97	122	147	172
23	48	73	98	123	148	173
24	49	74	99	124	149	174
25	50	75	100	125	150	175

May 1958

READER INFORMATION SERVICE

It is often difficult for advertisers to give all the technical details about their products in a limited amount of space. If you would like further information simply tick the appropriate numbers on the card opposite and mail to NUCLEAR POWER. *Also the following items not numbered*

NAME

NAME OF BUSINESS

ADDRESS

POSITION HELD

NATURE OF BUSINESS

Nuclear Power
THE JOURNAL OF BRITISH NUCLEAR ENGINEERING

1	26	51	76	101	126	151
2	27	52	77	102	127	152
3	28	53	78	103	128	153
4	29	54	79	104	129	154
5	30	55	80	105	130	155
6	31	56	81	106	131	156
7	32	57	82	107	132	157
8	33	58	83	108	133	158
9	34	59	84	109	134	159
10	35	60	85	110	135	160
11	36	61	86	111	136	161
12	37	62	87	112	137	162
13	38	63	88	113	138	163
14	39	64	89	114	139	164
15	40	65	90	115	140	165
16	41	66	91	116	141	166
17	42	67	92	117	142	167
18	43	68	93	118	143	168
19	44	69	94	119	144	169
20	45	70	95	120	145	170
21	46	71	96	121	146	171
22	47	72	97	122	147	172
23	48	73	98	123	148	173
24	49	74	99	124	149	174
25	50	75	100	125	150	175

May 1958

READER INFORMATION SERVICE

It is often difficult for advertisers to give all the technical details about their products in a limited amount of space. If you would like further information simply tick the appropriate numbers on the card opposite and mail to NUCLEAR POWER. *Also the following items not numbered*

NAME

NAME OF BUSINESS

ADDRESS

POSITION HELD

NATURE OF BUSINESS

SUBSCRIPTION CARD

Nuclear Power
THE JOURNAL OF BRITISH NUCLEAR ENGINEERING

YES!

I want my own PERSONAL copy!

Please send me NUCLEAR POWER for 12 months/until countermanded:

U.K. **£2. 2s. 0d.** + **10s.** postage

U.S.A. and Canada **$8.00** + **50c.** postage

Other countries **£3. 3s. 0d.**

starting with the _____ issue

☐ Subscription enclosed

☐ Invoice me later

NAME _____

SEND TO MY HOME/BUSINESS ADDRESS _____

Postage will be paid by Nuclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

Nuclear Power,
Rowse Muir Publications Ltd,
3 Percy Street,
London, W1
England

Postage will be paid by Nuclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

Nuclear Power,
Rowse Muir Publications Ltd,
3 Percy Street,
London, W1
England

Postage will be paid by Nuclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

Nuclear Power,
Rowse Muir Publications Ltd,
3 Percy Street,
London, W1
England

Tick No 33 on reply card for further details

SUCCESSFUL 'WIGNER RELEASE' IN RECENT B.E.P.O. TESTS

Vokes High Temperature Kompak chosen for this duty. Capacity of installation 150,000 c.f.m. at 200°C. Filters supplied and installed in seven days.

Vokes were glad of this opportunity of furthering the National interest by co-operating with A.E.R.E. Harwell.

VOKES

VOKES LIMITED · GUILDFORD · SURREY

Telephone: Guildford 62861 (6 lines) Telegrams & Cables: Vokesacess, Guildford, Telex Telex: 13-535 Vokesacess, Gfd.

Vokes (Canada) Ltd., Toronto *Vokes Australia Pty. Ltd., Sydney* *Represented throughout the World*

V 297

A33

CFW/V3

A34

CHEMICAL & PETROLEUM ENGINEERING EXHIBITION
OLYMPIA London 18-28 JUNE 1958

"Well, Fancy That!"

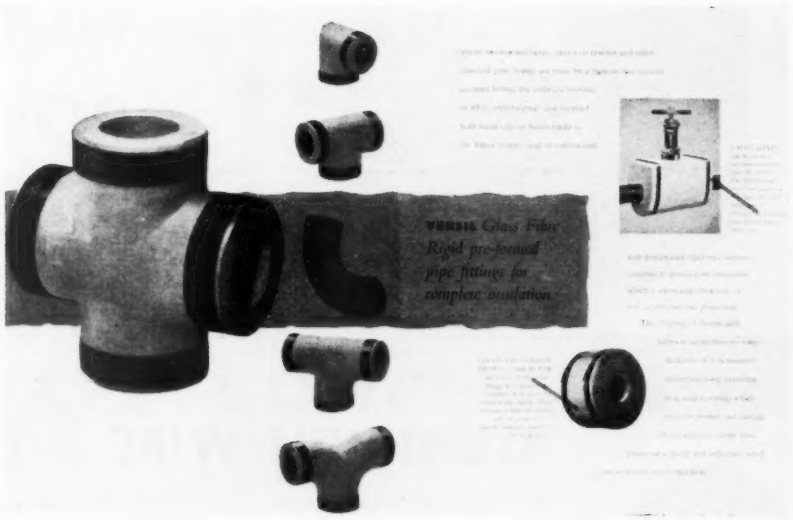
"Look—a personal letter of thanks from the G.M. himself . . .
. . . *and the Board has asked me to express our appreciation of your work over the last few years in reducing fuel costs. In particular, we consider your overhaul of our insulation and the installation of Versil Glass Fibre has saved the Company hundreds of pounds.* Well, what do you know . . ."

Not all Boards of Directors are as wide-awake as this one. But many are. And many more only need the right prompting . . . they only need to be told the facts about VERSIL GLASS FIBRE insulation. An illustrated brochure is available on request to Versil Limited, Rayner Mills, Liversedge, Yorkshire. Telephone: Cleckheaton 640

What You Need Is

Versil

THE GLASS FIBRE INSULATION

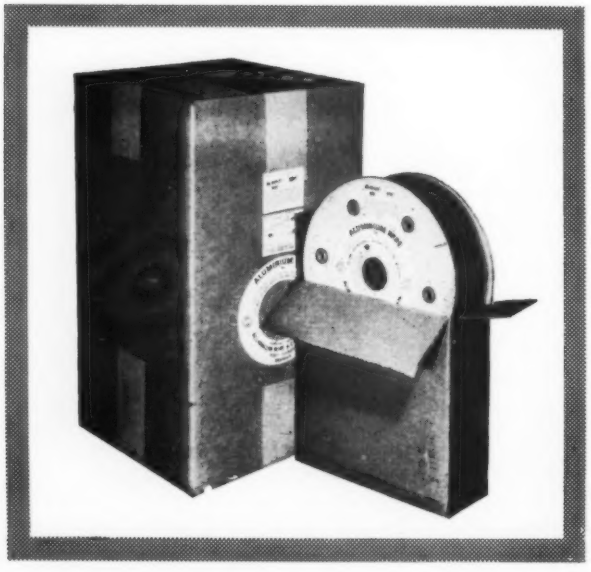


Reproduced from a new Versil publication— "THERMAL INSULATION"

Tick **No 36** on reply card for further details

Aluminium Wire

The production of high quality welds by the inert-gas metal-arc process demands the use of welding wire produced specially for the purpose. By specialising in the manufacture of such wire, AWCO ensure that all the exacting requirements are met. Untouched by hand after it has been subjected to a closely controlled surface treatment which provides the complete cleanliness so vital for the production of sound welds, the wire is precision wound on reels each containing 10lb. The reels are packed and sealed in individual cartons, five of which make a standard 50lb pack, thus ensuring against possible deterioration during storage.



for WELDING NUCLEAR POWER PLANT

For further details ask for publication No. G.23

ALUMINIUM WIRE & CABLE CO. LTD

Britain's largest Manufacturers of Aluminium Wire and Conductors

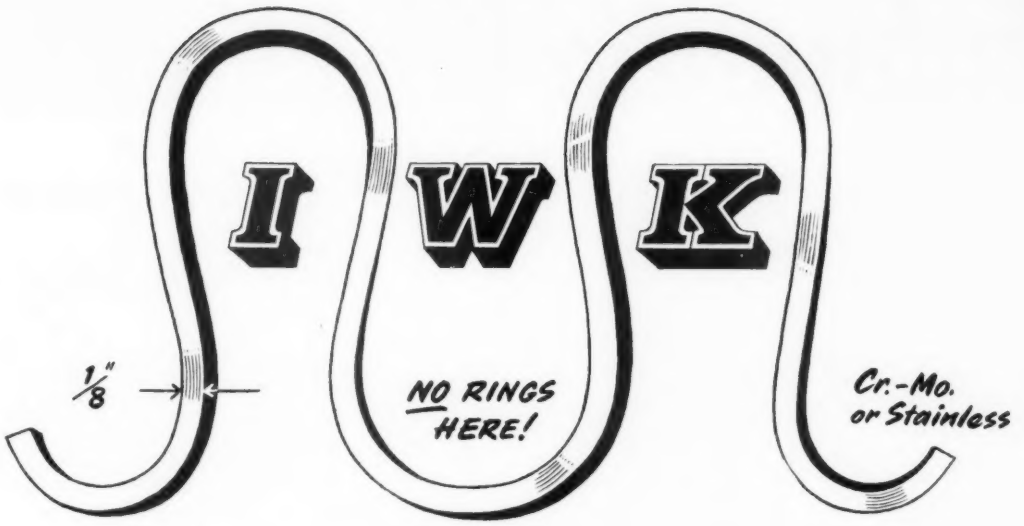
Head Office and Works: PORT TENNANT, SWANSEA, GLAMORGAN

Sales Office: 2 ST. JAMES'S SQUARE, LONDON, S.W.1. *Telephone: TRAfalgar 6441*

And at 13 COLMORE ROW, BIRMINGHAM 3. *Telephone: Central 2407*

AP 256

A36



Up to 48" High Pressure Units

In production for years . . . . . ✓

60" and 66" COMPLETE COMPENSATORS WITH ANCHORS

Officially supervised life and burst tests . . . . . ✓

You can have confidence in a tested unit!

IWK **STEEL COMPENSATORS**

Engineering Appliances Limited

NRP.1957

106 VICTORIA STREET · LONDON · S.W.1 · Telephone: Victoria 4043-4

Tick **No 38** on reply card for further details

Automatic Welding

now within reach of every shop!

ROCKWELD LTD

Autopak

introduces

100% USAGE

for Manual and Automatic Welding

POWER PACK

- For one or two manual operators or with Autopak continuous wire automatic head.
- Comparable in cost to a double operator welding transformer.
- It's British—practical—best value ever.

AUTOMATIC HEAD

- For submerged arc welding—CO_2 manual, automatic and fully automatic.
- No electronic components or delicate relays.
- Highly portable, compact and robust workshop unit.

ROCKWELD LTD

COMMERCE WAY · CROYDON · SURREY **Telephone : CROYDON 7161**

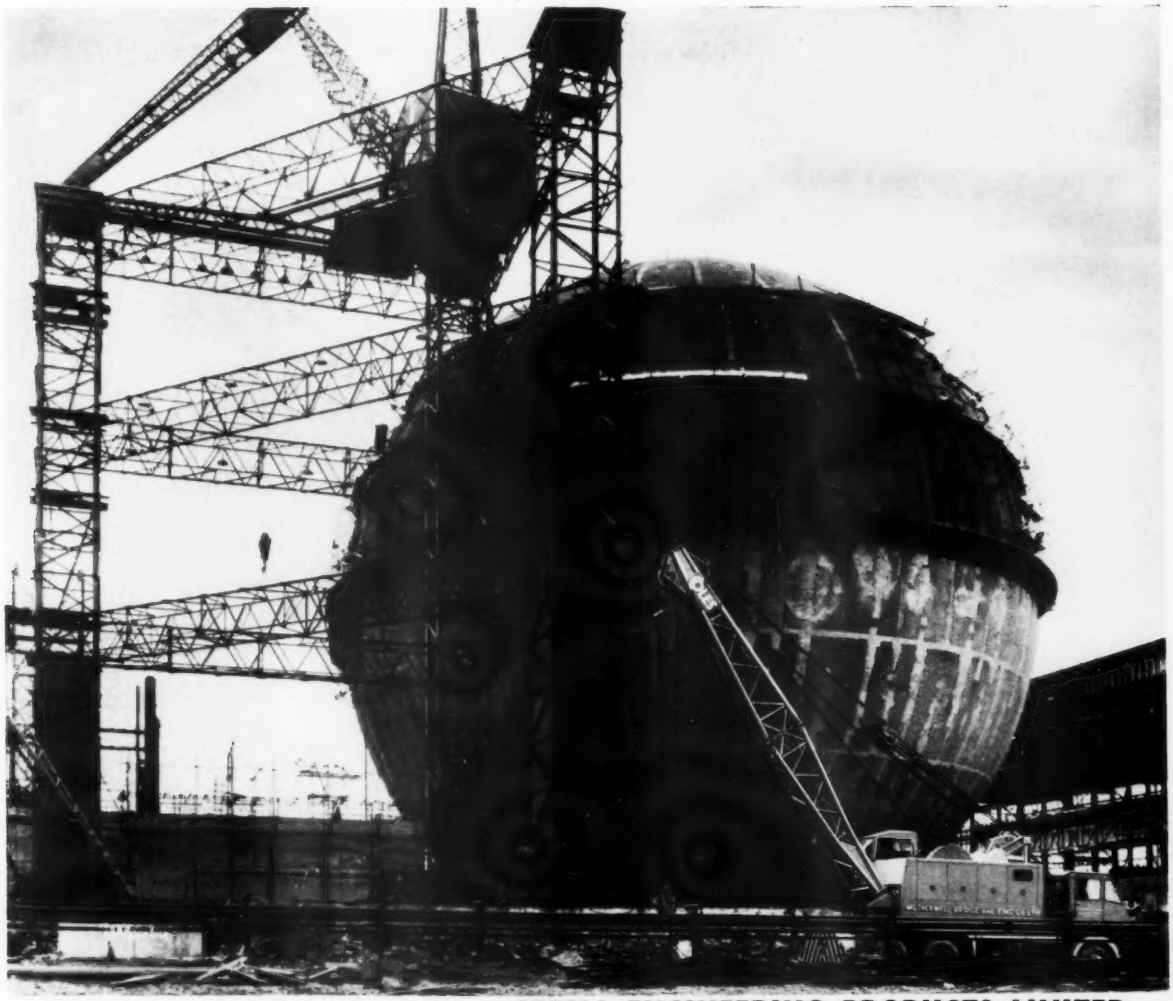
A38

Tick **No 39** on reply card for further details

COLES CRANE OF THE NUCLEAR AGE

The Power of the future demands a new standard in ancillary services.
In line with the rapid changes in techniques and values, created by this Nuclear Age, Coles have developed a new conception of design in a new range of Diesel-Electric Transmission Cranes.
All the features for which they are famous are embodied and attuned to keep pace with the challenge of scientific progress in the field of Nuclear Power.
WHERE COST COUNTS IT'S COLES.

One of the great new range



Designed, manufactured and marketed by:- **STEELS ENGINEERING PRODUCTS LIMITED**
Sunderland, England. **Tel: 56281 (10 lines) Grams: Steel, Sunderland**
SALES AND SERVICE: **Glasgow:** 235 Bath St., C.2 · **Newcastle:** Worswick Chambers, Worswick St., 1.
London: 143 Sloane St., S.W.1 · **Manchester:** 153 Oxford Rd., 13 · **Birmingham:** 39 Thorp St., 5.
COLES THE NAME THAT CARRIES WEIGHT

Tick **No 40** on reply card for further details

TWINNER

POSITIONING EQUIPMENT

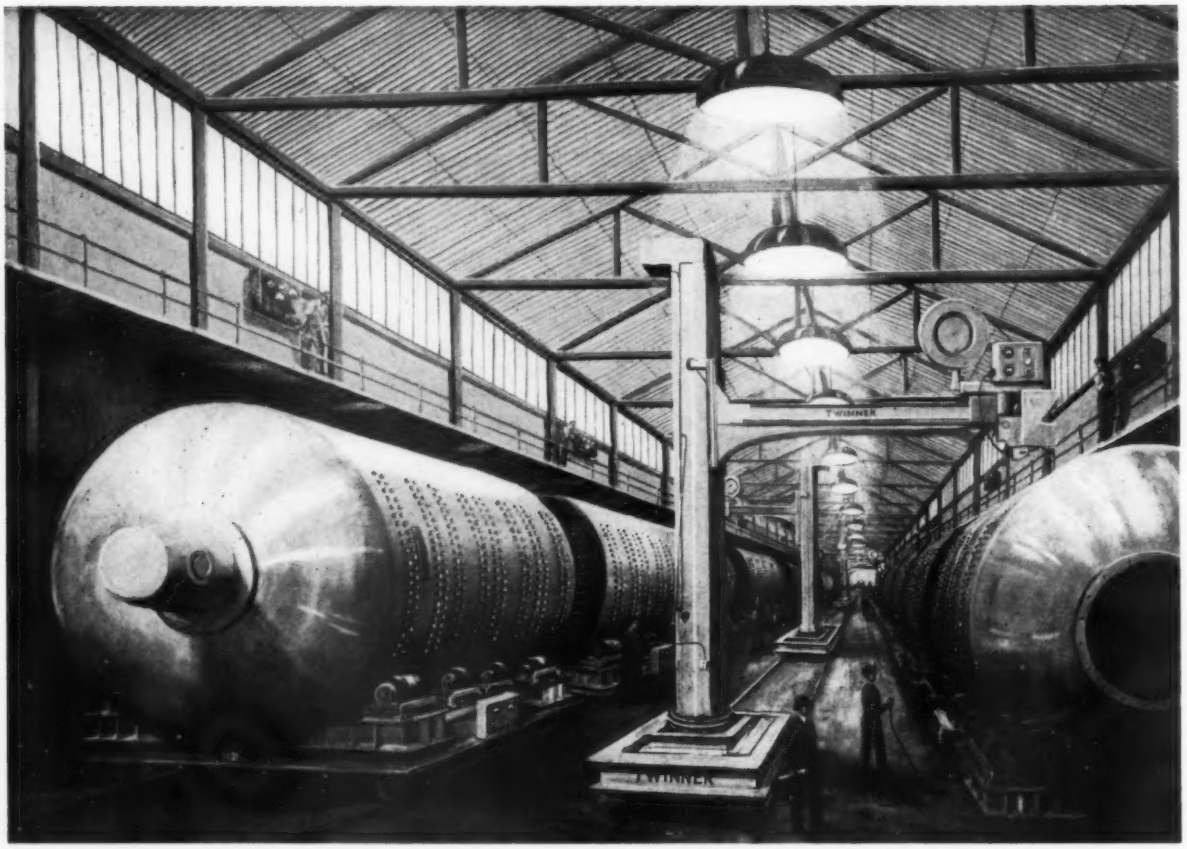
of

1275 TONS TOTAL CAPACITY

plays an important part in the construction of

NUCLEAR POWER STATIONS

at Berkeley and Bradwell



Specially designed manipulating plant required for lining-up, rotating and traversing the various sections of large Heat Exchangers during Welding, X-ray Inspection, Shotblasting and final Pressure Testing Operations is being supplied by:

Donald Ross ***and Partners Ltd.***

TWINNER WORKS, GATWICK ROAD, CRAWLEY, SUSSEX *Telephone: CRAWLEY 25061/3* *Cables: TWINNER, Crawley*

WELDED FABRICATIONS AND

Chemical plant

designed and built by an experienced team of creative engineers

to all standard specifications including LLOYDS, API-ASME, BSS 1500 and to meet the individual requirements of customers

by

EMPYRIUM

WELDING AND MANUFACTURING Company Limited

Pritchett Street, Birmingham 6

ASTon Cross 3203/4/5

pioneers in welding practice since 1917

JW. AD 4079

"This is a job for IMHOFS standard raks..."

"We can get quantity delivery in 7 days, too!"

RAKS in 29 different types and sizes —in any quantity—straight off the shelf! That's what Imhofs special service to the Nuclear industry means. By buying standard units you are relieved of all the worry of construction and show a marked saving in production costs. There are Imhofs standard raks and cases to suit every kind of instrument and electrical apparatus—and 'specials' can be supplied at short notice to suit individual requirements. Write now for catalogues and full details.

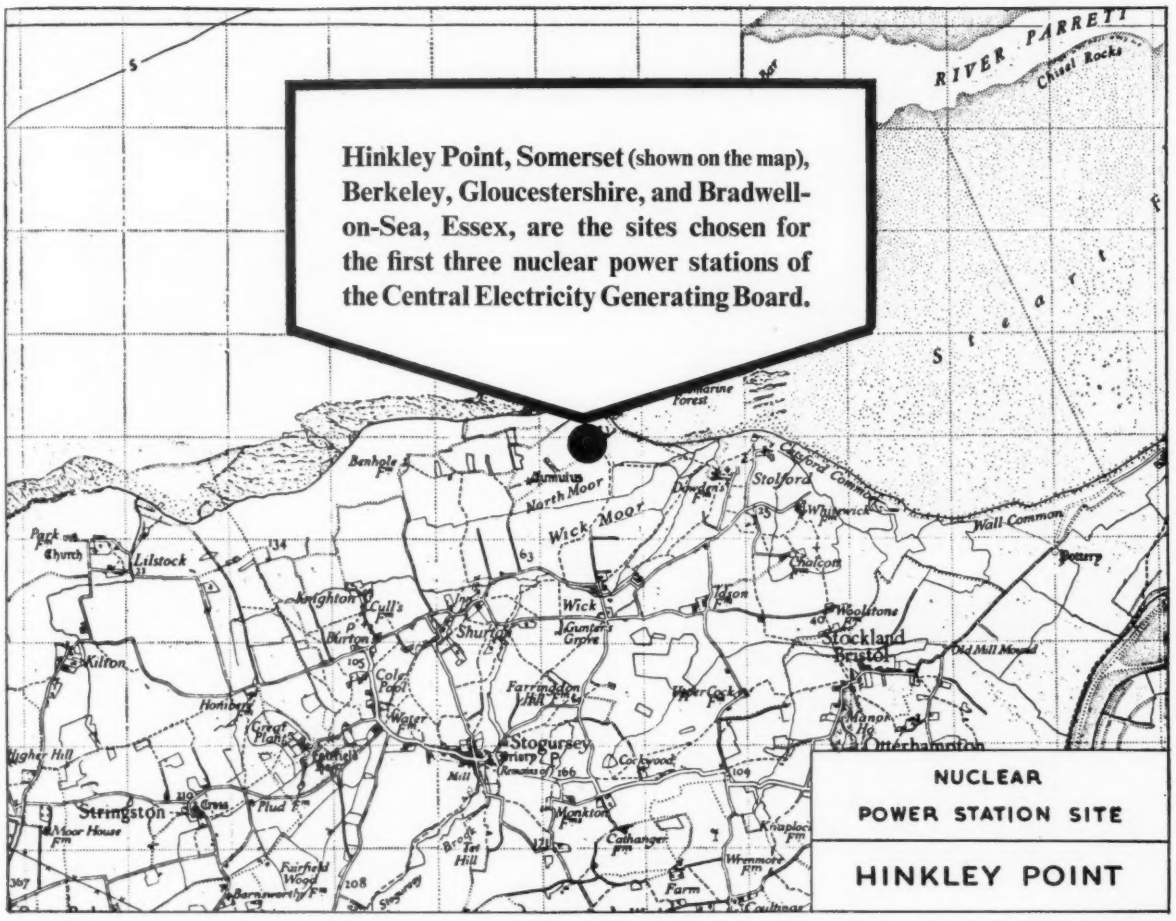
29 STANDARD RAKS TO CUT YOUR COSTS & SAVE YOU TIME

Imhofs standard raks are available in 29 different sizes, with one or more bays as required. Precision-built from fine materials, beautifully designed and finished, they are available for delivery *ex stock* within 7 days. Handles and other accessories can also be supplied at once.

FOR CASES IT'S IMHOFS

ALFRED IMHOF LIMITED Dept. N5 Ashley Works, Cowley Mill Road, Uxbridge, Middlesex Tel: UX5—5567
Export & London Showrooms: 112-116 New Oxford Street, WC1 Tel: MUSeum 7878

Electricity from Nuclear Energy



Crown Copyright Reserved

The growing need for power

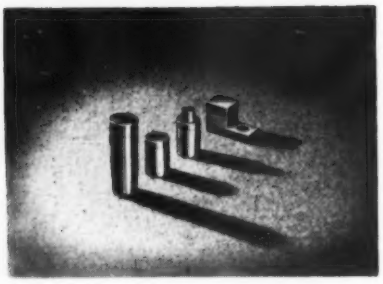
As Britain's industrial efficiency increases, so does the need for power. The demand for power doubles every ten years. The electricity supply industry has already met the doubled demand since 1st April, 1948, and has made provision for a similar expansion in the next decade.

Work on the first two nuclear power stations, at Berkeley in Gloucestershire and Bradwell in Essex, was started in January, 1957, and on the third in England, at Hinkley Point in Somerset, last September. These three stations will have an aggregate of some 850,000 kilowatts.

The Government's revised nuclear power station programme provides for enough nuclear power stations to be completed in the next decade to provide 5-6 million kilowatts of generating capacity. Provision is also being made for the construction of new main transmission lines.

As the demand for power grows, nuclear energy will become more and more important as a source of electric power, upon which the economic future of the country so largely depends.

THE CENTRAL ELECTRICITY GENERATING BOARD



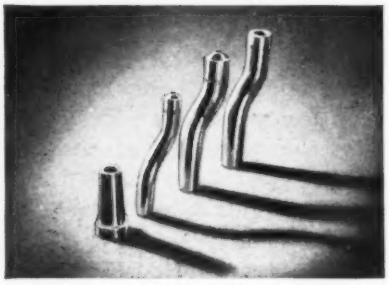
FOR ALL YOUR RESISTANCE WELDING NEEDS

...call ERM

E R M resistance welding electrode materials can meet a lot of your requirements from Stock.
Have you our Information Sheets detailing all Stock items?

Copper Tungsten Materials now available—
for Projection Welding Dies and
Flash Butt Welding Inserts specify CW1.
For Hot Riveting Dies specify CW2.

Recent additions to our extensive stocks are a range of Double Bend Electrodes, a Double Bend Adaptor and a Straight Adaptor.



ENFIELD ROLLING MILLS LTD

BRIMSDOWN · ENFIELD · MIDDLESEX · TELEPHONE: HOWARD 1255

Tick No 45 on reply card for further details

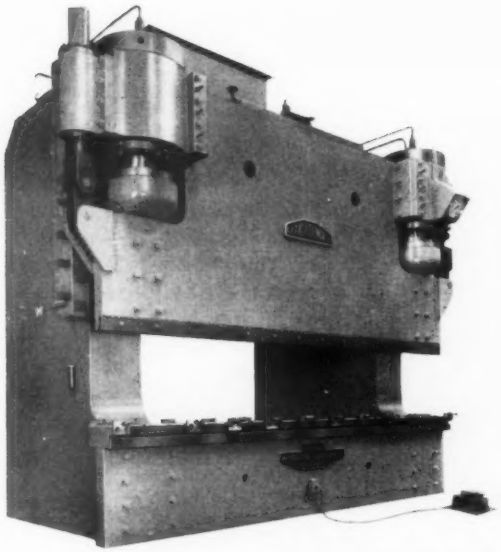
corporation limited

A heavy set of BENNIE Plate Bending Rolls, with power operation to all motions and adjustments. Made in various sizes up to 25 ft. maximum length (1¼ in. plate) and 2 in. maximum thickness (16 ft. length).

BENNIE Machines also include Guillotine and Rotary Shears; Plate Edge Planers; 7-roller Plate Straightening Rolls; Punching, Shearing and Cropping Machines; Beam Benders.

plate and bar working machine tools

SCOTTISH machine tool



CRAIG & DONALD Hydraulic Press Brake, made up to 500 ton capacity, with every refinement for the most accurate and speedy work.

CRAIG & DONALD Machines also include light Bending Rolls and Guillotines; Folding & Bending Machines; Section Curving Rolls; Angle Straighteners; 4-roller Plate Straightening Rolls; Plano-Guillotines; Power Presses.

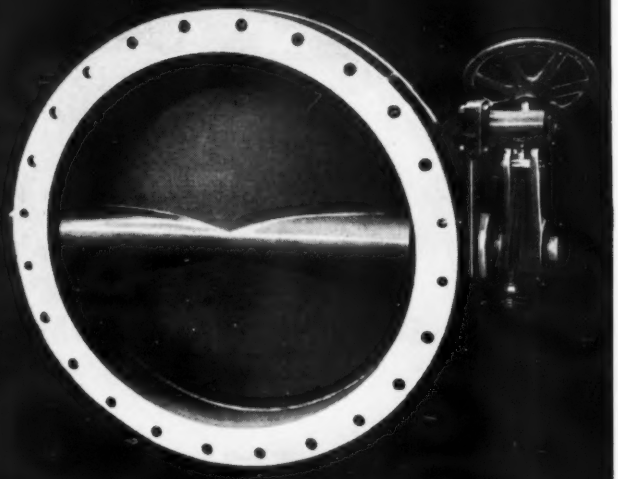
17 Lynedoch Crescent, GLASGOW C.3. *Douglas* 6586-9
58 Victoria Street, LONDON S.W.1. *Victoria* 2106
2 Sir Harry's Road, Edgbaston, BIRMINGHAM 5. *Calthorpe* 2541
The Building Centre, Brunswick Terrace, LEEDS 2. *Leeds* 25250

Boving

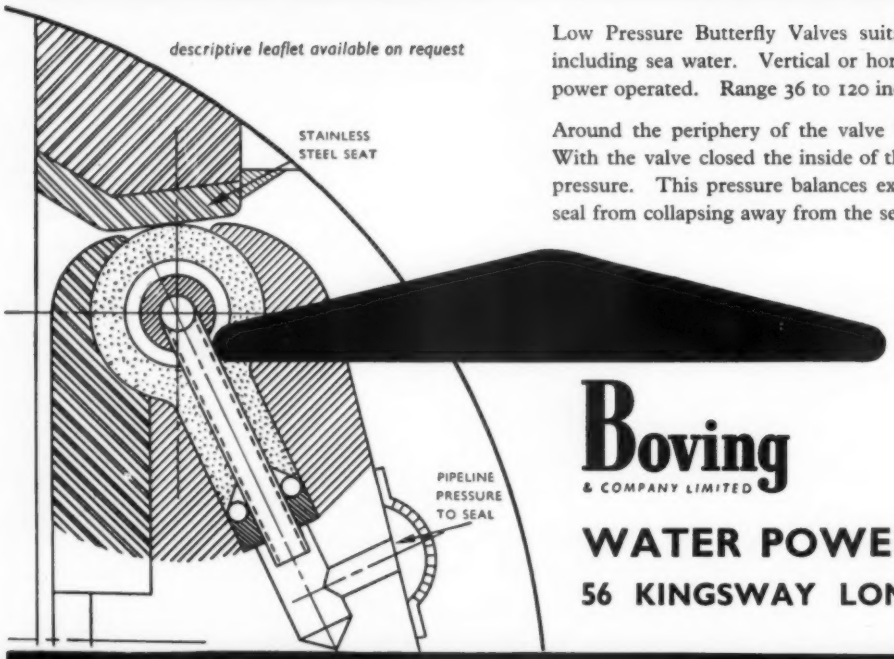
low pressure butterfly valves

- DROPTIGHT
- COMPACT
- LOW COST
- NON-JAMMING
- SEALING BY AUTOMATIC INFLATION

The reliability of this patented method of sealing has been proved in hydro-electric installations—after 25 years of service at heads up to 500 ft *the original seals were still intact.*



descriptive leaflet available on request



Low Pressure Butterfly Valves suitable for gases and fluids—including sea water. Vertical or horizontal mounting. Hand or power operated. Range 36 to 120 inches. Larger sizes to order.

Around the periphery of the valve blade is the expanding seal. With the valve closed the inside of the seal is subject to pipe-line pressure. This pressure balances external pressure and prevents seal from collapsing away from the seating.

Boving
& COMPANY LIMITED

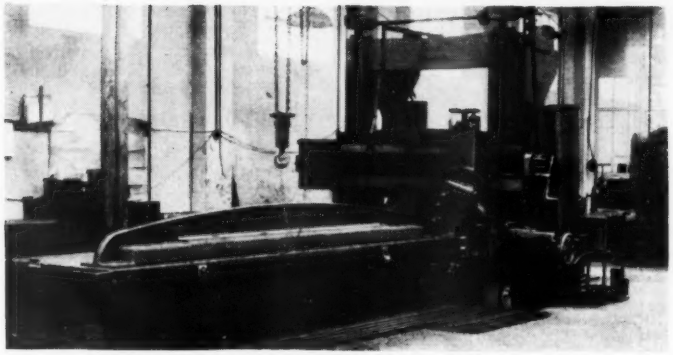
WATER POWER ENGINEERS

56 KINGSWAY LONDON W.C.2

P1554

Tick **No 47** on reply card for further details

ATOMIC ENERGY REQUIRES OUR PRECISION ENGINEERING



Planing machine capacity 16 ft. × 5 ft. × 5 ft.

PRECISIONS LTD.

Two of three jig borers. Capacity 28 ins. × 28 ins.

LET 25 YEARS EXPERIENCE SOLVE YOUR MEDIUM PRECISION ENGINEERING PROBLEMS

In parallel surface tables 24 ft. × 5 ft.

All work carried out in a spacious, modern well-equipped factory of good height for crane lifting.

CONTRACTS COMPLETED FOR—

NGTE PYESTOCK
AERE HARWELL
AWRE ALDERMASTON

- **DESIGN OFFICES FOR SPECIAL PURPOSE MACHINES, ETC.**
- **AID & ARB APPROVED.**
- **ALL WORK CHECKED BY MICRO-ALIGNMENT TELESCOPES AND ACCESSORIES.**

AERO PRECISIONS LTD.

WATERWORKS ROAD
FARLINGTON
PORTSMOUTH

Phone : Cosham 76832-3

Tick **No 48** on reply card for further details

HICYCLE equipment was used to grind down the welds on this fast fission breeder reactor of the U.K.A.E.A. at Dounreay. *Reproduced by courtesy of The English Electric Co. Ltd.*

Whichever way you look at it

. . . there's an awful lot of welding in that sphere. And a lot of grinding, too. To ensure rapid completion of this grinding operation, the major part was carried out with HICYCLE portable electric tools.

HICYCLE power tools were the ideal choice for a job of this magnitude because their constant speed at all loads removes metal at such a high rate—greater than any other type of hand held tool.

What is Hicycle?

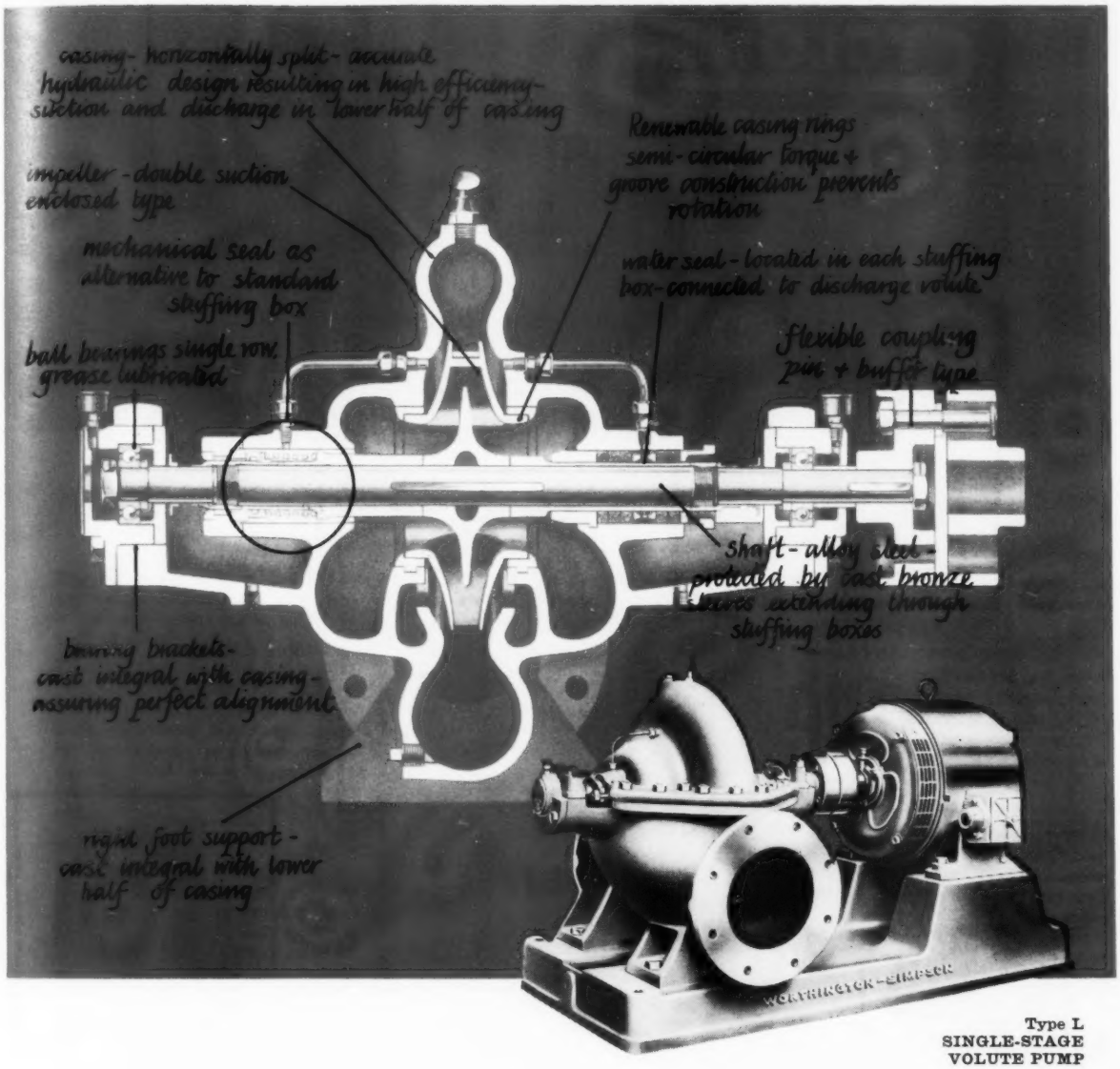
A range of electric tools that increase the output per man by sustained high working speed under load, achieved by stepping up the electricity supply to 200 cycles. As much as 75% overall time saving is shown on many jobs. Write for Hicycle Catalogue.

A typical HICYCLE grinder in use.

Hicycle ELECTRIC PRODUCTION TOOLS

made by **Consolidated Pneumatic**

CONSOLIDATED PNEUMATIC TOOL CO. LTD., 232 DAWES ROAD, LONDON, S.W.6.
CP148


casing - horizontally split - accurate hydraulic design resulting in high efficiency - suction and discharge in lower half of casing
impeller - double suction enclosed type
mechanical seal as alternative to standard stuffing box
ball bearings single row grease lubricated
bearing brackets - cast integral with casing - assuring perfect alignment
rigid foot support - cast integral with lower half of casing
Renewable casing rings semi-circular torque + groove construction prevents rotation
water seal - located in each stuffing box - connected to discharge volute
flexible coupling pin + buffer type
shaft - alloy steel - protected by cast bronze sleeves extending through stuffing boxes
WORTHINGTON-SIMPSON

Type L
SINGLE-STAGE
VOLUTE PUMP

easy access to the interior

Worthington-Simpson single and two-stage horizontal split-casing centrifugal pumps are available in capacities from 15 to 15,000 G.P.M., heads up to 550 feet depending upon capacity. Suction and discharge nozzles are integral with the lower half of the pump, and the upper half can be removed without disturbing shaft alignment or connections. These pumps will operate in series with any type of drive and are particularly suitable for applications where high efficiency and low maintenance costs are required.

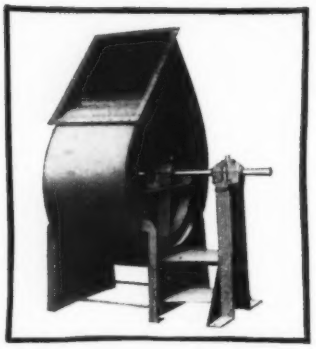
Worthington - Simpson Ltd **NEWARK NOTTS**

P686

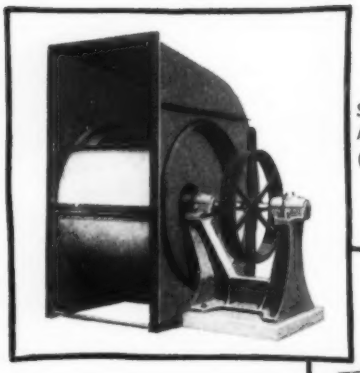
Tick **No 50** on reply card for further details

CYCLONE

FANS AND EQUIPMENT

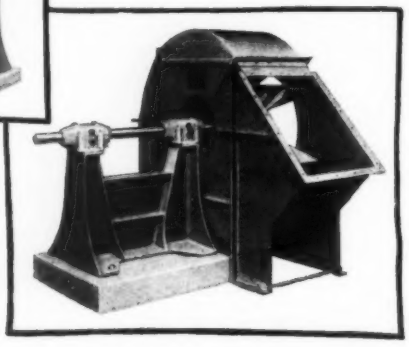


SLOW SPEED MULTIVANE FAN (Intermediate size).

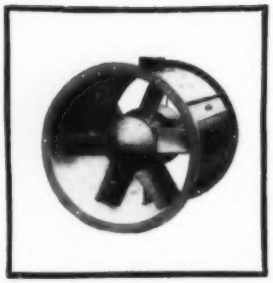


SLOW SPEED MULTIVANE FAN (Large size).

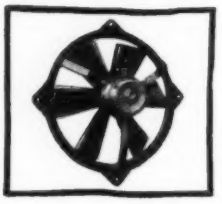
Air ways are our ways



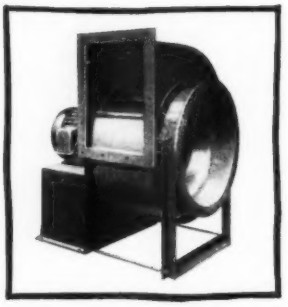
PADDLE BLADE FAN.



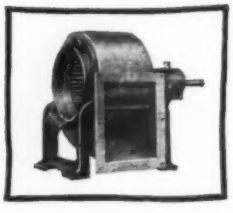
AXIAL FLOW FAN.



PROPELLER FAN.



P.V.C. FAN.



SLOW SPEED MULTIVANE FAN (Small size).

Ventilation, dust collection, fume removal and cooling industrial "hot spots" are jobs for Cyclone Fans and Allied Equipment. 75 years' experience, technical advice and comprehensive literature is yours on request.

MATTHEWS & YATES LTD.

CYCLONE WORKS · SWINTON (MANCHESTER) & **135 RYE LANE, PECKHAM, LONDON S.E.15**

TELEPHONE: SWINTON 2273 (4 lines) TELEPHONE: NEW CROSS 6571 (4 lines)

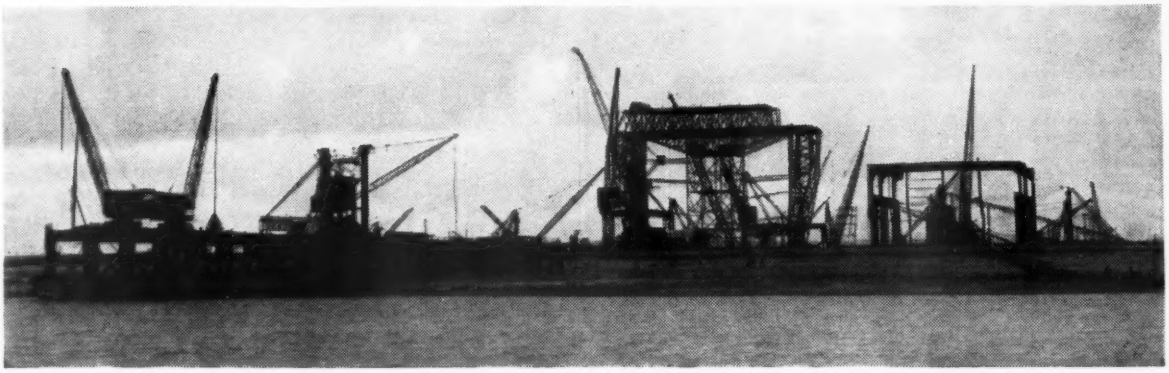
Also at: Glasgow · Leeds · Birmingham · Cardiff · Bournemouth

9026

A50

Tick **No 51** on reply card for further details

Progress report on **BRADWELL**



1 THE FIRST YEAR . . .

January 18th, 1958, was the first anniversary of the start of construction of Bradwell nuclear power station in Essex, England.

The station was designed, and is being built, by the Nuclear Power Plant Company Limited for the Central Electricity Generating Board. Employing two gas-cooled, graphite-moderated reactors, the station will have a guaranteed net electrical output of 300 megawatts.

TURBINE HALL

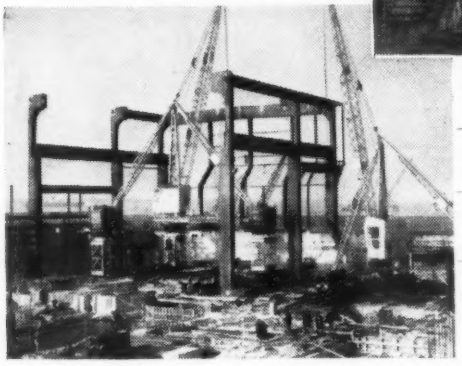
The reinforced concrete foundation blocks for the main and auxiliary turbo-alternators have been completed and the outer retaining walls are above ground level from an excavation depth of approximately 24 ft. Structural steelwork, carried on mass concrete foundations, is now being erected. The dimensions of the turbine house excavations are 550 ft. x 200 ft.

REACTOR PROGRESS

Both reactor buildings are now above ground level from an excavated depth of 40 ft. The support plinths for the pressure vessels have been cast, and work has started on the fabrication of the vessels.

GOLIATH CRANE

This 200-ton crane to be used primarily for the fabrication of the reactor pressure vessels and the hoisting of complete boiler shells has been completed. Running on tracks on each side of the reactor buildings the bridge structure will clear the buildings at any time. The track of approximately 1,200 ft. length is also nearing completion.



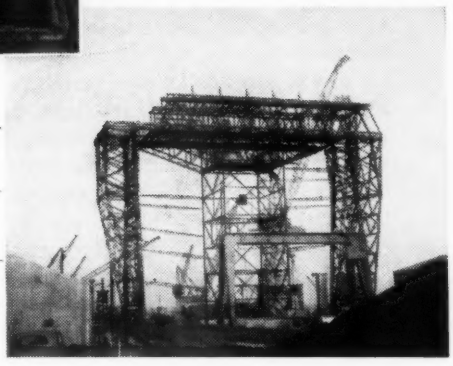
Top *A view of site from Blackwater estuary*

Above *Nos. 1 and 2 Reactors*

Left *Northern end of the Turbine Hall*

Right *The Goliath Crane*

These photographs were taken during the first year of Progress.



THE NUCLEAR POWER NPPC PLANT COMPANY LTD.

BOOTHS HALL · KNUTSFORD · CHESHIRE

TGA NP4

AS1

Tick **No 52** on reply card for further details

Butterfield

LIQUID NITROGEN STORAGE VESSELS

For low temperature work in nuclear research

TESTS CONDUCTED ON A 300 GALLON VESSEL SHOW AN EVAPORATION RATE OF ONLY ·66°/₀ EVERY 24 HOURS

Butterfield Stainless Steel (Mild Steel Jacketed) Storage Vessels of 300 gallons capacity and upwards, are now employed in a number of Nuclear projects. Their duty is holding supplies of liquid nitrogen to be used for two purposes . . . that of cooling down both the plant for liquefying hydrogen and the hydrogen itself. Liquid hydrogen, in turn, is required for many problems in nuclear research.

AS FABRICATORS to the United Kingdom Atomic Energy Authorities, Butterfields have supplied or are now at work on Storage Vessels such as the 300 gallon type illustrated and larger capacities, for the following: *Ministry of Supply. Nuclear Physics Research Laboratory, Liverpool University. University of Birmingham. Royal Society Mond Laboratory, Cambridge. Rolls-Royce Limited. The Plessey Company. The Butterley Company. Conseil Européen pour la Recherche Nucléaire. U.K.A.E.A. Research Establishment, Aldermaston. Standard Telephones & Cables Ltd. Clarendon Laboratories, Cambridge.*

We are equipped with Weld X-Ray Plant, materials testing and microscopic examination facilities for any required class of work

please mark all enquiries relating to this advertisement as follows: N/P/5

W. P. Butterfield Limited P.O. Box 38 Shipley Yorkshire Tel. 52244 (8 lines)

Branches: LONDON Tel HOLborn 2455 (4 lines) BIRMINGHAM Tel EAS 0871 & EAS 2241 BRISTOL Tel 27905 LIVERPOOL Tel Central 0829 MANCHESTER Tel Blackfriars 9417 NEWCASTLE-ON-TYNE Tel 23823 GLASGOW Tel Central 7696 BELFAST N.I. Tel 57343 DUBLIN Tel 73475 & 79745

Bailey's and Atomic Energy

1949 WINDSCALE PLUTONIUM PILES

1951 CAPENHURST DIFFUSION FACTORY

1953 CAPENHURST DIFFUSION FACTORY

1953 CALDER 'A' PRELIMINARY WORKS

1954 CALDER 'A' MAIN CONTRACT

1955 CAPENHURST DIFFUSION FACTORY

1956 CALDER 'B' MAIN CONTRACT

1957 BERKELEY NUCLEAR POWER STATION
A.E.I.-JOHN THOMPSON NUCLEAR ENERGY CO. LTD.

1957 WINDSCALE WORKS

N. G. BAILEY & CO., LTD.

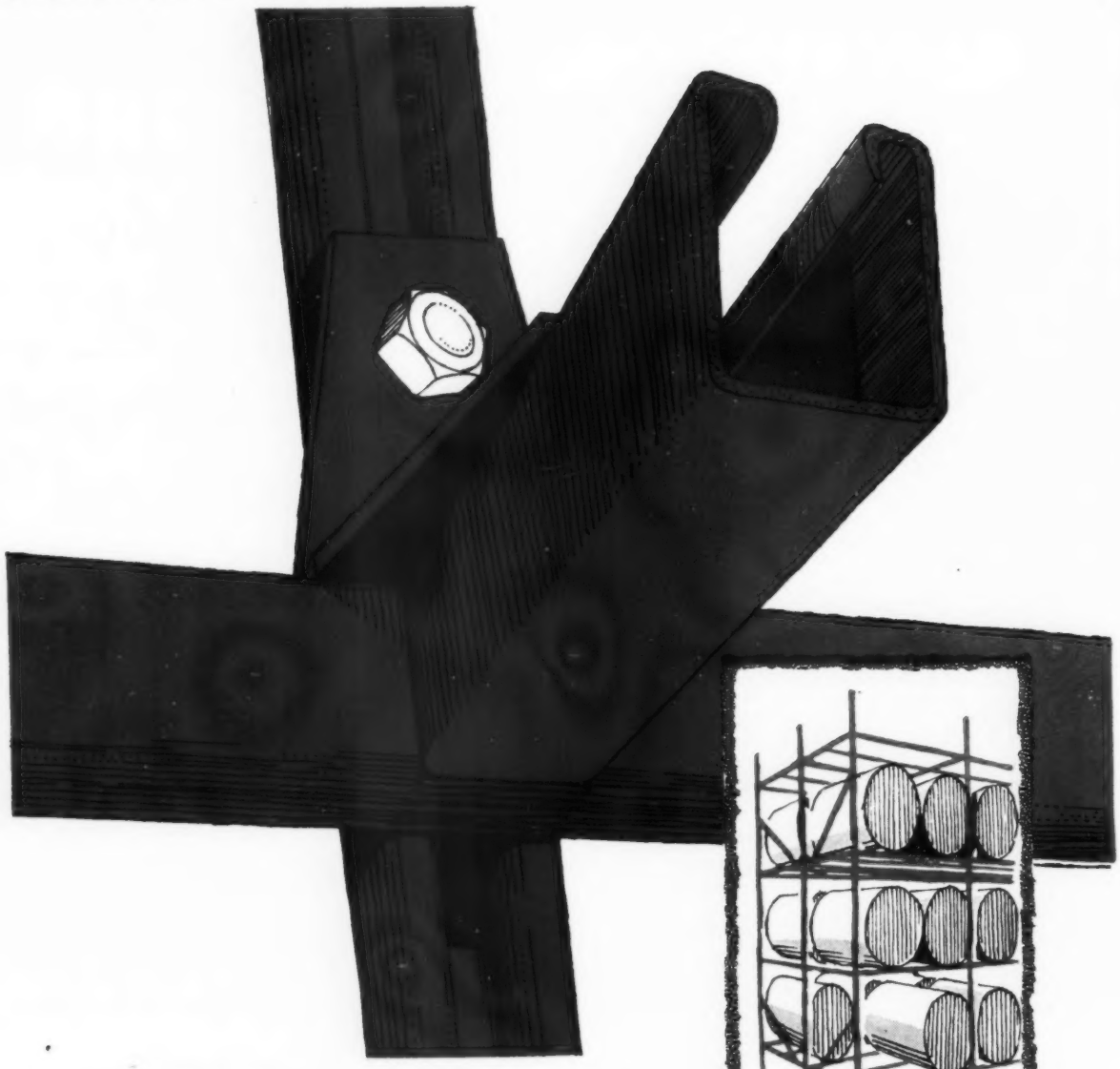
Electrical Engineers

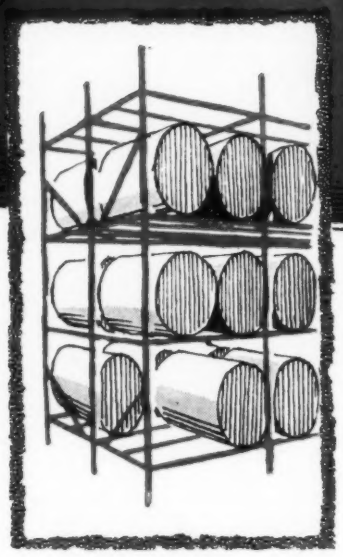
BURLEY VALE WORKS, KIRKSTALL ROAD, LEEDS, 4

Phone: LEEDS 637854

London *Persian Gulf* *Manchester*

Tick **No 54** on reply card for further details





UNISTRUT

STANDARDISED

SPEED AND ECONOMY IN PURPOSE-MADE SUPPORT STRUCTURES

Unistrut components—steel channel for framing and a comprehensive range of specific-purpose components—are standardised round a brilliantly simple, ultra-rapid self-locating nut assembly. Whatever the requirements of the individual job, Unistrut enables you to build a correct, economical support structure *at the minimum on-site cost*. It's a matter of fundamental design. Please write for details to the address below.

FOR RACKING, PIPING AND ELECTRICAL INSTALLATIONS, AND ALL FRAMING APPLICATIONS

UNISTRUT DIVISION OF SANKEY-SHELDON LTD., DEPT.NP61, 46 CANNON STREET, LONDON, E.C.4

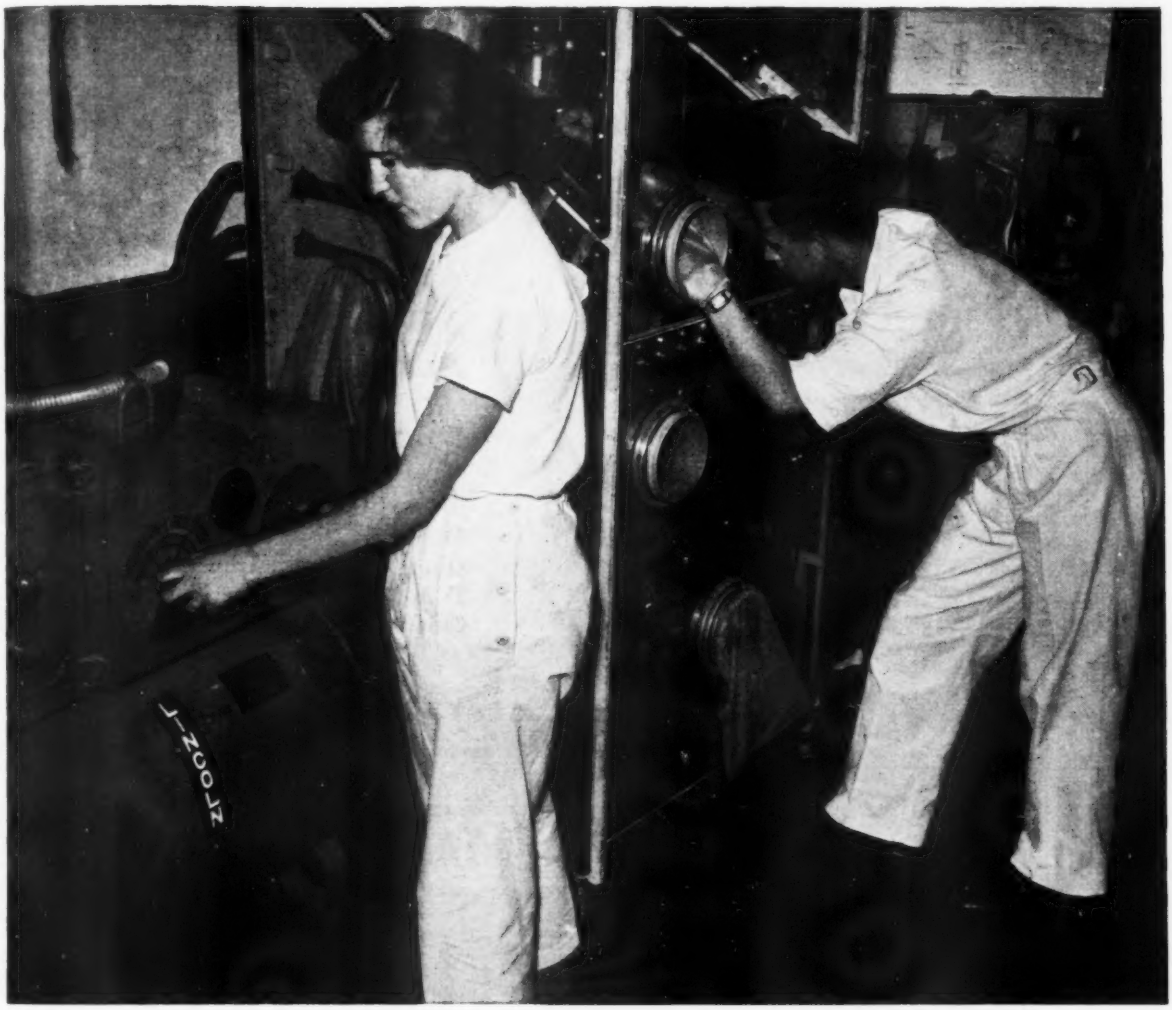
Telephone: CITy 4477. Telegrams: Sankeshel, Cannon-London.

54

AS4

Tick **No 55** on reply card for further details

FIRST IN THE FIELD—AND STILL IN THE LEAD



Seeing is Believing!...

Of course, we've always known that our D.C. Motor Generators are simplicity itself when it comes to control and adjustment, and the above picture surely proves our point (without any disrespect to the fair sex).

Ease of control is only one of the many outstanding features of these versatile and compact power units, the arc characteristics of which are designed to provide the operator with just the right type of arc to suit the job.

The above photograph shows a Lincoln SAE.300 Motor Generator in action at the A.E.R.E., Harwell, Berkshire, supplying current to the furnace which melts samples of plutonium alloys; just one of the many applications so suitable for Lincoln welding units in the development of Nuclear Power.

For full details of the complete Lincoln range of D.C. motor generators —from the SA.150 ampere workshop 'Junior' to the SAE.900 ampere for Fully Automatic Submerged Arc Welding, please write to:—

CHEMICAL AND PETROLEUM ENGINEERING EXHIBITION
18th-28th June, 1958
See the full range of Lincoln Electric Welding Equipment at Stand No. 2A (Ground Floor) Grand Hall, Olympia.

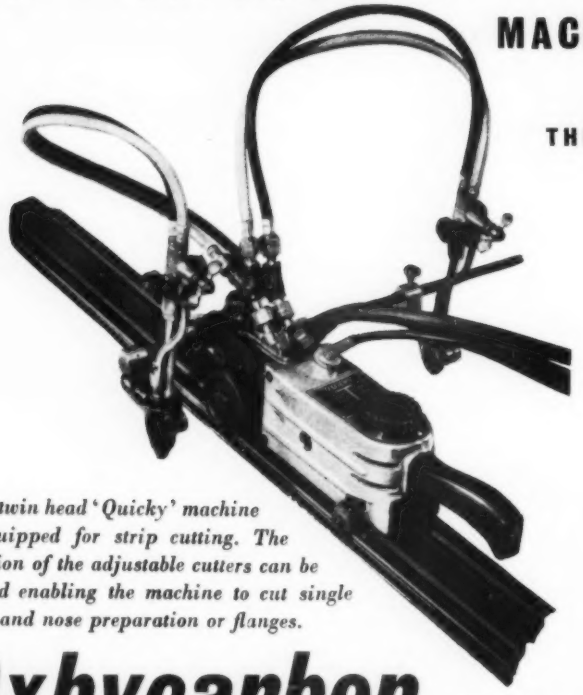
LINCOLN ELECTRIC CO LTD

WELWYN GARDEN CITY · HERTS · WELWYN GARDEN 920 (5 lines) 4581 (5 lines)

824

Tick **No 56** on reply card for further details

More than 10,000 OF THESE REMARKABLE LITTLE MACHINES HAVE BEEN SOLD



This twin head 'Quicky' machine is equipped for strip cutting. The position of the adjustable cutters can be altered enabling the machine to cut single bevel and nose preparation or flanges.

THE *'Quicky'* SPECIFICATION

Total weight of machine: 13 lb.

Power: Fractional h.p. motor 220/240, 110 or 50 v. AC/DC

Cuts steel plate from $\frac{1}{8}$" to $2\frac{1}{2}$"

A special cutter is available for cutting a plate less than $\frac{1}{8}$"

Circle cutting from $2\frac{1}{2}$" to 40" in diameter

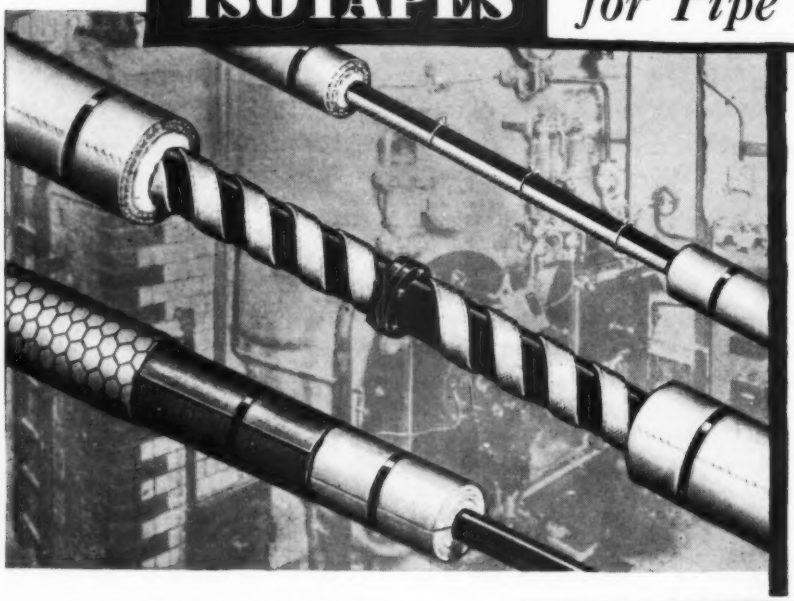
Light weight tongued and grooved steel track is available in 3' 3" lengths

Price:

Single cutting head machine	**£50**
Twin head cutting machine	**£68 15 0**
Guide rails	**£2 5 6 each**

Oxhycarbon CO. LTD. CROYDON SURREY ADDiscombe 7691

ISOTAPES *for Pipe Tracing...*



The wide range of tapes from 3 to 150 foot lengths in five loadings from 5 to 40 watt per foot allows you to choose the correct unit for any heating or compensating duty. Easily and quickly applied, terminations at one end.

A glance at the graphs in our leaflet shows you the required loading— Please ask for it!

Spiralled for higher temperatures and larger bores. Straight traced for general use, fuel feed lines and frost protection.

ISOPAD LIMITED
Barnet By-Pass, Boreham Wood, Herts.
Phone: ELStree 2817/8/9.

ISOPAD ELECTRIC SURFACE HEATERS

Tick **No 57** on reply card for further details

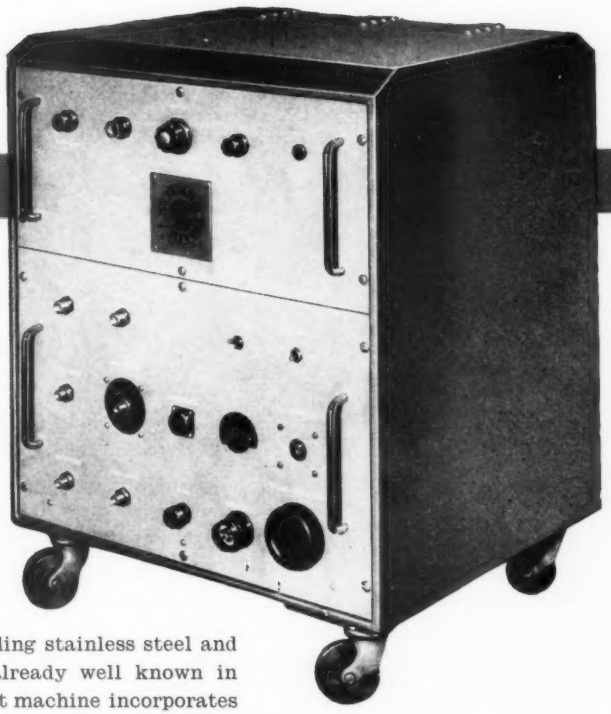
A56

Tick **No 58** on reply card for further details

THE NEW SATURN-HIVOLT

Surge Injector

Argon Arc Welding Unit Mk. 1a



permits continuous welding up to 300 amps

The Argon Arc process for welding stainless steel and aluminium and its alloys is already well known in industry. The new Saturn-Hivolt machine incorporates forced draught ventilation and the surge injection principle of arc maintenance. It is capable of continuous arc welding up to 300 amps from a 42 volts A.C. open circuit supply. This gives complete safety to the operator and considerable running economy. The arc is stable and starts from cold without a carbon block and the control of gas and water supplies is entirely automatic.

Machine Dimensions

Mk. 1a. 30" high by 25" wide and 28" long. This machine is mounted on castors and is both compact and mobile.
We also manufacture and distribute a wide range of Argon Arc Welding Torches, B.G.T. cutting and welding equipment and accessories. These, together with a daily delivery of Argon, Pyrogas etc., and a rapid equipment maintenance service are available at all our branches—Birmingham, Glasgow, Lymington, Manchester, Sheffield, Sunderland, Thornaby-on-Tees.

SATURN HIVOLT MADE IN ENGLAND

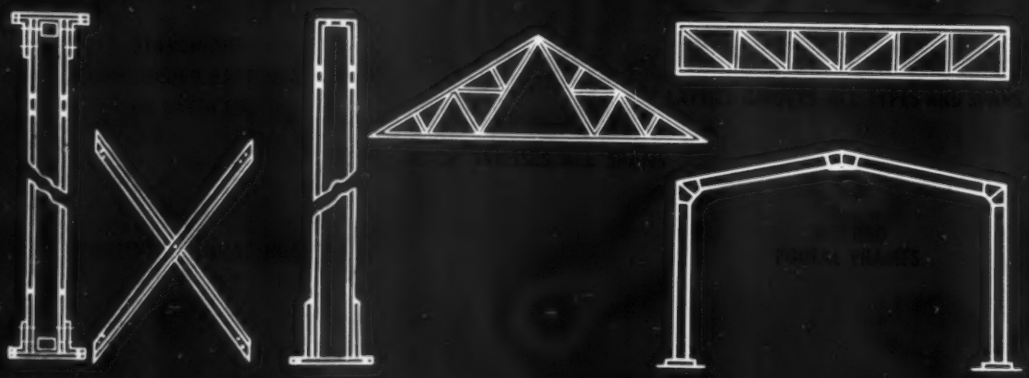
Contractors to:—
The Admiralty
The Air Ministry
The Ministry of Supply
U.K. Atomic Energy Authority
Australian Atomic Energy Authority.

SATURN INDUSTRIAL GASES LTD., SATURN WORKS, GORDON ROAD, SOUTHALL, MIDDLESEX

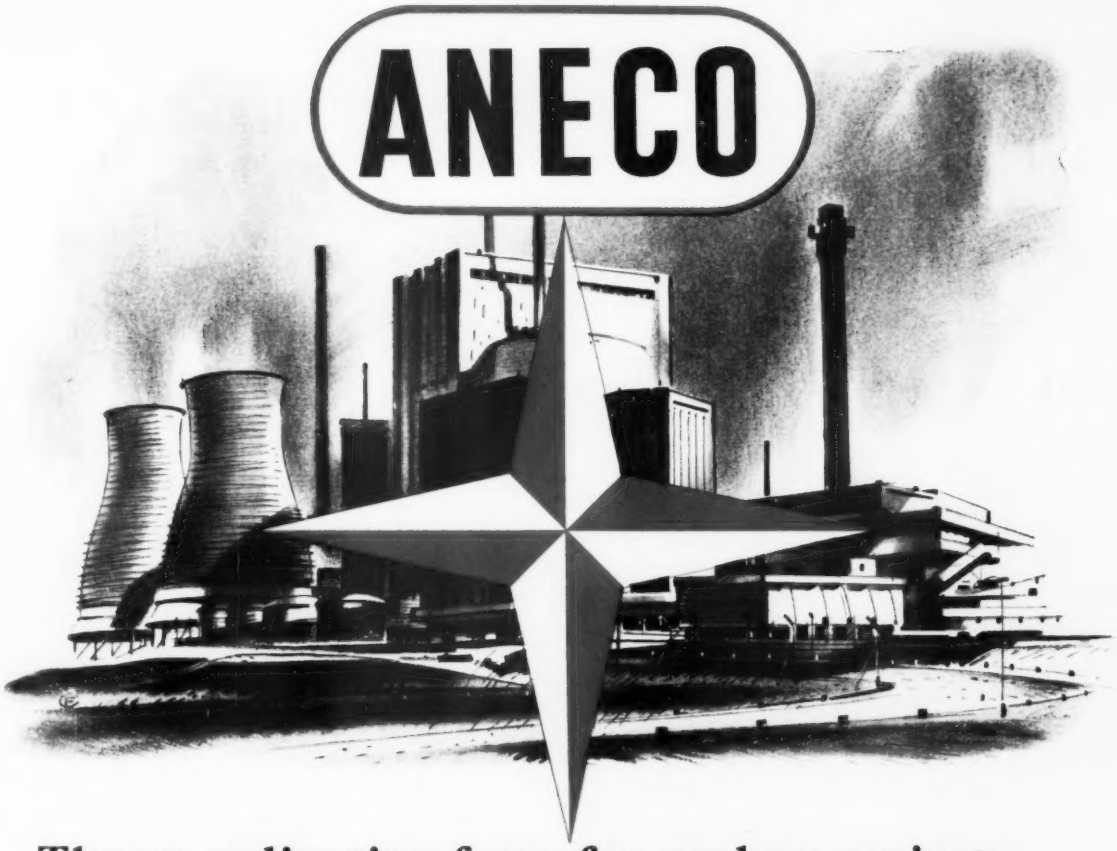
Tick No 59 on reply card for further details

RIVETED WELDED STEELWORK

SKINNINGROVE



Tick **No 60** on reply card for further details

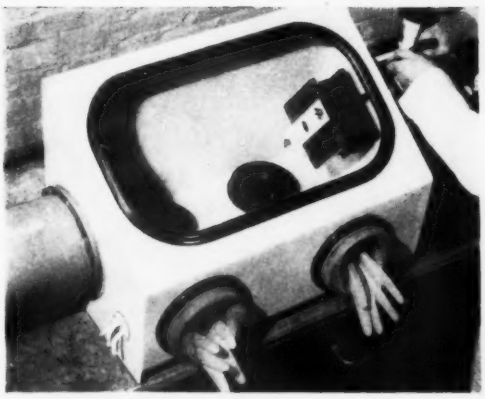


The co-ordinating force for nuclear projects

In a new world of industrial endeavour where ideas may evolve and succeed each other even before prototypes become production units, it can be comforting to know that a centralised organisation exists to advise and channel enquiries for nuclear equipment.

ANECO combines the resources of a group of companies with over seven years experience of varied nuclear projects. Enquiries to ANECO lead to contact with the appropriate production unit within the group, saving time and simplifying procedure in the initial stages for all concerned. ANECO is thus the focal point from which to start ; whether you require pilot plant or equipment from fine precision components to 10-ton fabricated units. The majority of the equipment produced by ANECO can be to Harwell specification.

GLOVE AND DRY BOXES	ELECTRONIC EQUIPMENT
ELECTRO-MAGNETS	ELECTRICAL CONTROL DESKS AND PANELS
PRESSURE AND VACUUM VESSELS	LAMINATED PLASTICS
FURNACES	SIGNS, DIAGRAMS AND LABELS
REACTOR COMPONENTS	VACUUM AND FIBREGLASS MOULDINGS
HANDLING TONGS	PRINTED CIRCUITS



ANECO Mark 111c GLOVE BOX
One of a range of Glove Boxes
Made under Licence from U.K.A.E.R.E.
Mild Steel Construction
Complete with Ancillary Equipment

AYLING NUCLEAR EQUIPMENT CO.

AYLING INDUSTRIES GROUP

Consulting Organisation for

H. & E. LINTOTT LTD. — HAMBLING INDUSTRIES LTD.

BRIBOND LTD.

AYLING HOUSE, KINGS ROAD, HORSHAM, SUSSEX. Tel. HORSHAM 3391

Tick **No 61** on reply card for further details

Improved efficiency for NUCLEAR APPLICATIONS with *CON-TEN*

FOR LOAD OF UP TO FOUR TONS AND MOVEMENT OF UP TO EIGHTEEN INCHES

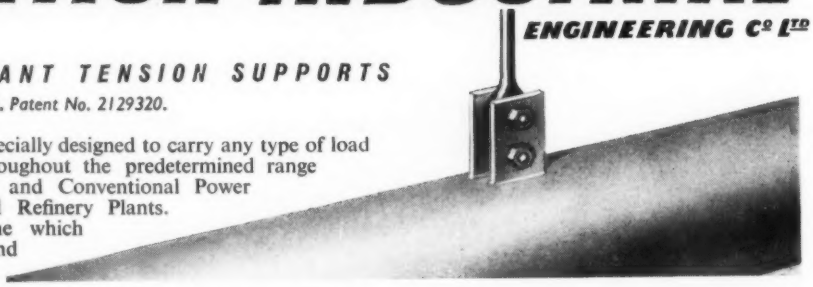
BRITISH INDUSTRIAL

ENGINEERING Co LTD

CON-TEN CONSTANT TENSION SUPPORTS

British Patent No. 474008. U.S.A. Patent No. 2129320.

" Con-Ten " Supports are specially designed to carry any type of load under constant tension, throughout the predetermined range of movement, for Nuclear and Conventional Power Stations, Chemical and Oil Refinery Plants. It is acknowledged as one which produces minimum friction and kinematic variation.



CORONATION WORKS, HAINGE ROAD, TIVIDALE, TIPTON, STAFFS. *TEL: TIPTON 1222*

A60

Tick **No 62** on reply card for further details

IT'S HERE!

Fielden's new industrial level controller

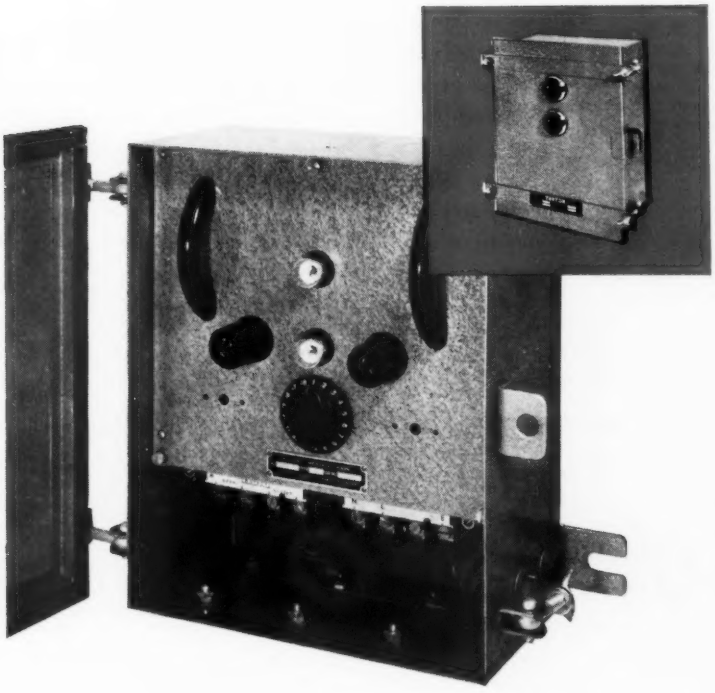
9 points which make the Fielden

Tektor Major

REGD

the most advanced level controller available to industry

1. Cable length up to 35 ft.
2. Sensitivity with stability
3. Triggered, positive relay action
4. Easily adjusted, calibrated set-point control
5. Printed circuits for reliability
6. Quick release chassis for ease of installation and maintenance
7. For any supply from 110 to 440v, 40-60 c/s.
8. Industrial, weatherproof cases
9. Robust approved terminal blocks



In 1949 Fielden Electronics Ltd., pioneered the original capacity operated level controller which was known as the Tektor. We firmly believe that the advent of the Tektor MAJOR marks the biggest single contribution to the technique of accurate and reliable level control since that date.

Fielden

FIELDEN ELECTRONICS LTD · WYTHENSHAWE · MANCHESTER · Phone: Wythenshawe 3251 (4 lines) Grams: Humidity Manchester
ALSO AUSTRALIA ITALY CANADA & U.S.A. *Branch Offices* LONDON · WALSALL · STOCKTON-ON-TEES · EDINBURGH

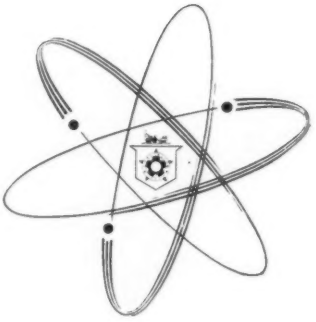
NUCLEAR ENGINEERING cannot tolerate faulty design or ill-chosen materials. Every inch of a plant that houses such enormous energy has to be designed and constructed to highly critical specifications. That is why such contracts go only to the cream of industry.

For this reason we at the Darlington Insulation Company are particularly proud to list, among our many major achievements, the honour of being the first insulation contractors to work on a British nuclear power station.

The Calder Hall project involved a succession of new problems during construction, the testing nature of which was just another challenge successfully met by the skill of our engineers.

Your insulation problems (whether heat, cold or sound) call for the same wide experience, the same awareness of new developments in engineering, as well as suitable materials of proven efficiency.

A talk with one of our technical representatives will cost you no more than a letter or a 'phone call. The Darlington Group of Companies are always at your service and would be pleased to help you right away. Ring Newcastle 23666 and tell us your problem now.

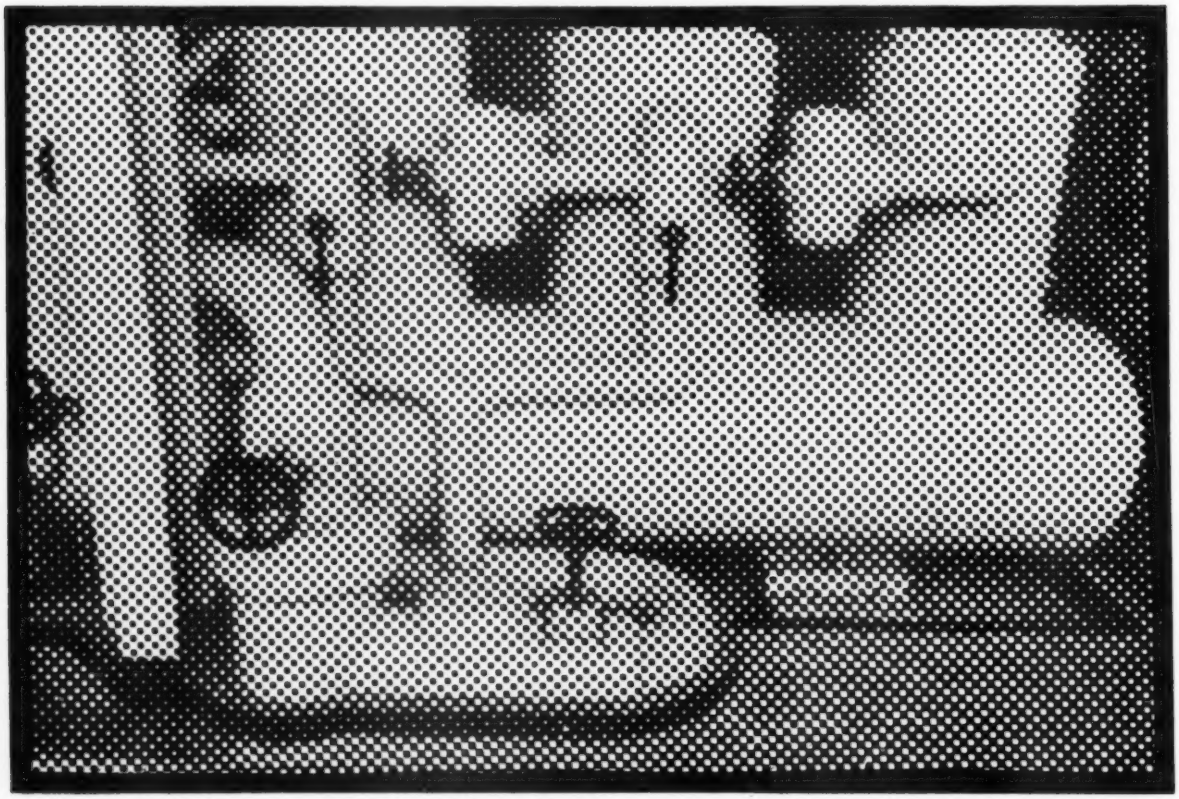


THE DARLINGTON INSULATION CO. LTD

Head Office: 38 Great North Road, Newcastle upon Tyne

Branch Offices at: London, Birmingham, Bolton, Bristol, Cardiff, Glasgow, Leicester, Sheffield

H9



Tick **No 64** on reply card for further details

COLLOIDAL GRAPHITE ...in electronic and allied fields

Coatings or films formed with this versatile product are, for practical purposes, chemically and physically inert; they can be used in close proximity to radio-active material and are transparent to radio-active emanations. The many applications for 'dag' colloidal graphite include the lubrication of reactor control mechanisms, louvres and sliding surfaces; the treatment of screw threads to prevent seizure, dry film and high temperature lubrication for I/c engines, air compressors, pumps, reduction gears, and for ball roller or plain bearings under conditions of high load, stress or speed

An Acheson service engineer will be pleased to call on you, or technical leaflets will be sent on request.

dag
REGD TRADE MARK
DISPERSIONS

ACHESON COLLOIDS LIMITED
(A subsidiary of Acheson Industries (Europe) Ltd.)
PRINCE ROCK · PLYMOUTH · DEVON
Tel. No. Plymouth 66351 Telegraphic Address: "Oildag" Plymouth

Nuclear Power
THE JOURNAL OF BRITISH NUCLEAR ENGINEERING

MAY 1958 VOLUME 3 NUMBER 25

MANAGING DIRECTOR ..... A. H. David Rowse MA (Cantab)
EDITOR ..... William Davidson MSc (Eng) DIC
FEATURES EDITOR ..... Patricia May BSc
NEWS EDITOR ..... John Woodeson BSc (Eng)
EDITORIAL ASSISTANTS ..... Ralph Brock, Angela Funnell
PRODUCTION MANAGER ..... The Hon Gerald Vane BA (Cantab)
CIRCULATION ..... F. M. Rice

CONSULTANT EDITORS
INSTRUMENTATION ..... Denis Taylor PhD, MIEE, FInstP, Northampton
PHYSICS ..... James F. Hill BSc, Harwell
METALLURGY ..... Prof J. G. Ball BSc, FIM, London
ISOTOPES ..... A. G. Maddock MA, PhD, DIC, Cambridge

ADVERTISEMENT DIRECTOR ..... Harry T. Kane
ADVERTISEMENT MANAGER ..... John Abram
BIRMINGHAM OFFICE ..... Trevor N. Bertram
MANCHESTER OFFICE ..... Harry C. Aikin
NEWCASTLE OFFICE ..... Peter Doig
NEW YORK OFFICE ..... Walter J. Masterson Jr

IN THIS ISSUE

WELDING SYMPOSIUM

Introduction 206
Special problems in nuclear energy 207
I. H. Hogg, Risley
Pressure vessel manufacture 210
H. Harris, Babcock & Wilcox Ltd
Heat exchanger manufacture 213
P. K. Richards, John Thompson Water Tube Boilers Ltd
Welding aluminium and its alloys 215
N. T. Burgess, Aluminium Development Association
Welding magnesium alloys 217
I. H. Morrison and A. F. Taylor, Springfields
Welding the rarer metals 219
D. R. Harries and J. G. Purchas, Harwell
Fabrication of corrosion and heat resisting steels 222
J. A. McWilliam, Firth-Vickers Stainless Steels Ltd
Non-destructive testing 224
F. S. Dickinson, Risley
Buyers' Guide to welding equipment 227

NEWS FEATURE

Harwell: successful Wigner release 230

PROGRESS IN INDUSTRY

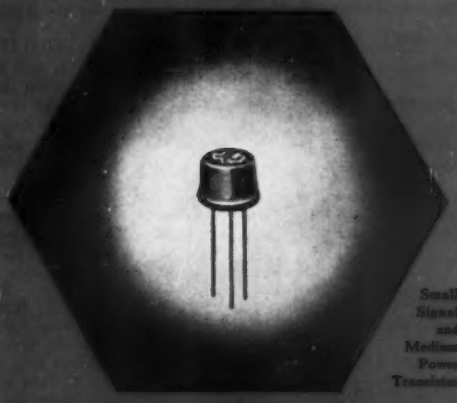
Goliath crane in action 234
Site report from Bradwell
Towards improved reactors 236
GEC expands research facilities

REGULAR FEATURES

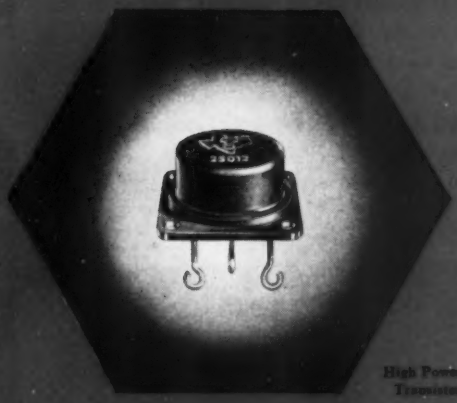
Publisher's Column A65
Letters to NUCLEAR POWER A67, A69
Leader A71
Worldview 201
Equipment 231
Companies 238
Cross Section *Gracchus* 241
Institutions 242
Books 246
Names in the News 248
Catalogues & Bulletins 248
Research Reports 250
Patents 252

ROWSE MUIR PUBLICATIONS LIMITED
3 PERCY STREET, LONDON, W1. MUSEUM 8252

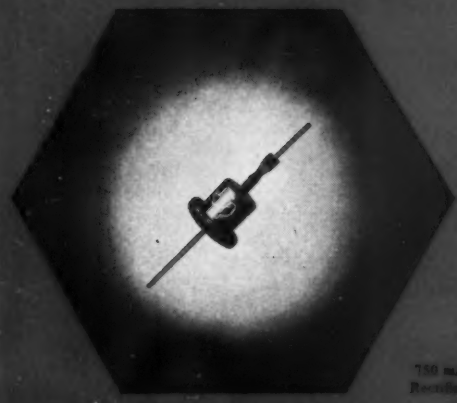
HERE and NOW TEXAS HAVE THE RANGE...



Small Signal and Medium Power Transistor



High Power Transistor



750 mA Rectifier

All illustrations are actual size

Silicon Transistors

Small Signal

This range of general purpose transistors is used for high gain, low level applications. Special features are :— negligible leakage current, a minimum alpha cut-off frequency up to 20 Mc/s, and a tetrode series providing 16 db gain at 30 Mc/s.

Medium Power

These 4-watt diffused base silicon transistors are ideally suitable for output stages in servo amplifiers. A pair in push-pull operation provide sufficient power to drive many types of servo motors. Two types are available, one with a maximum collector voltage of 60, the other of 100; the former is particularly useful for operating from 28-volt battery supplies.

High Power

Texas high-power transistors permit remarkable miniaturisation of power equipment. A collector dissipation of 37½ watts with complete reliability, in such a small device can only be achieved by using silicon. Furthermore, these transistors have a typical alpha cut-off frequency of 5 Mc/s.

Silicon Diodes

Medium Power

The new Texas diffused silicon technique has brought a fundamental change in semiconductor rectifiers. Peak inverse voltages up to 600 are featured in each of two ranges now readily available:— a metal-case rectifier provides a mean rectified current of 750 mA, and a glass-seal type provides 400 mA together with a forward to reverse current ratio of $2 \times 10^6 : 1$.

Computer Diodes

These miniature glass sealed diodes have a maximum recovery time of 0.3 micro sec with a forward current rating of 100 mA; there are three types with P.I.V. ratings of 50, 100 and 150 volts. The capacitance is 2.7 pico-farads at – 10 volts, 1 megacycle.

Complete data sheets are available on request.

TEXAS INSTRUMENTS LIMITED

DALLAS ROAD · BEDFORD · TEL: BEDFORD 68051 · CABLES TEXINLIM BEDFORD

T.7

As the reactor temperature rises . . .

The attainment of higher operating temperatures in the reactor is dependent on far reaching problems which may take some years to overcome.

One of the outcomes of this technical development will be the need for ever higher standards of thermal insulation to counteract the increase in fuel consumed in producing this valuable high temperature heat.

The insulating materials required for this application will have to combine structural strength and durability with superlative insulating properties and the ability to withstand high temperatures without shrinkage or distortion, in fact, just the properties offered by the Fosalsil range of insulating bricks, concretes and lightweight slabs, which are currently in wide use for lining power station boilers.

●

MOLER PRODUCTS LTD.
HYTHE WORKS - COLCHESTER

Publishers Column

On the Fringe

Recently the Federation of British Industries held a conference at Eastbourne designed mainly to interest at director level firms that could play a part in nuclear energy or its products. This is a splendid idea and we are sure the delegates found much to ponder on. We also regard this as a most important function for us, and although much of our contents is designed to appeal to specialists of one sort or another, the observant reader will notice that we always include a proportion of material of direct appeal to what have become known as 'fringe firms.'

Many have been the times when the Editor has been approached by firms with the enquiry—'our firm make so-and-so which are widely used in the such-and-such industry: can you tell us how our product could be used in nuclear energy. If it needs modification or adaptation we are quite willing to do this if only we know what is wanted.' Sometimes we can answer these questions right away: sometimes we have to make quite a few enquiries before we are in a position to reply. But nearly always we can help, and indeed on some occasions we have given the firm a very useful lead which has led to real business.

As a result of this NUCLEAR POWER is now being taken not only by the firms who are already deeply involved in nuclear energy but also to a greatly increasing extent by others whose work begins to impinge on this great new industry and who hope at some stage to be able to join it. Thus we, too, by our function of disseminating information, are helping to build Britain's nuclear industry.

Safety, fast and last!

Those are the three virtues you'll find in a *Norton BD Reinforced Wheel. Safety* in the double reinforcement—a strong integral fabric, and a tough safety web moulded into the hub side. *Fast* clean cutting without spalling or loading. *Lasting* quality that gives the maximum work per wheel.

Use Norton BD Reinforced Wheels for cutting down, cleaning up and bevelling, rough grinding and finish grinding on welds. These versatile wheels last longer, cut faster, provide the greatest safety. Ask your Norton or Alfred Herbert representative about them—or write to us at Welwyn Garden City.

NORTON ABRASIVES

NORTON GRINDING WHEEL CO. LTD.
Welwyn Garden City, Herts. Tel.: Welwyn Garden 4501 (10 lines)

Enquiries also to: **ALFRED HERBERT LTD., COVENTRY**

NORTON *and* BEHR-MANNING *factories also in Argentina, Australia, Brazil, Canada, France, Germany, Italy, Northern Ireland, South Africa and U.S.A.*

NGW BD/135

SIR! LETTERS TO NUCLEAR POWER

Miniaturized components unreliable ?

SIR: In the excellent article by Mr B. C. Godbold in your April issue (*Instrumentation trends in nuclear power stations*—page 157) he casts some doubt on the reliability of miniaturized components and recommends that their incorporation in electronic equipment should be approached with caution. I certainly agree that any innovations in nuclear power plant require most careful consideration but in the matter of miniaturization I wonder if his doubts really have much substance. After all, miniaturized components are now being used in a great many diversified applications and I would have thought that their performance was now satisfactory. Failures can of course occur in any electronic components but if the assembly is miniaturized it can generally be replaced complete with very little trouble if a stock of spares is held.

Romford, Essex. J. W. NAYLER

Let's do it ourselves

SIR: Gracchus seems to have his knife into the *Dreadnought* project and suggests that we should sell out to the Americans. No doubt it is true that the Royal Navy must take a back place when compared with the United States and Soviet fleets but we still remain a leading nuclear power and we should be ashamed just meekly to copy the *Skate*. I am sure we can do the job ourselves—and just as well. In any case I do not see how we can obtain anything in the way of classified information from the Americans as long as their Atomic Energy Act remains in force.

Solihull, Warwicks. B. MAGGS

▶ *Gracchus writes—'I regret as much as anybody the situation in which we find ourselves, but if submarines are needed at all they are needed quickly. Accepting this as a fact, the most expeditious way of getting them would seem to be as I suggested. This depends utterly of course on American cooperation and one simply doesn't know how far this extends! Ed.*

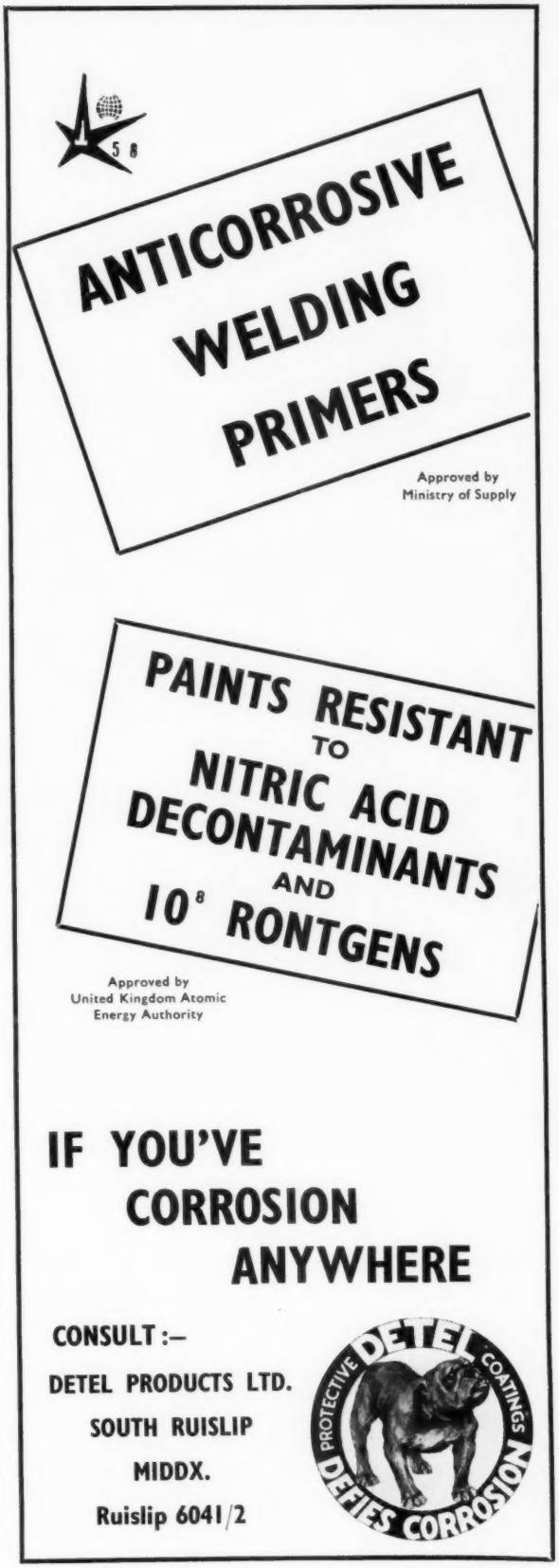
In the beginning

SIR: In your March 1958 issue, you included a letter from P. F. Cartwright concerning the origin of the word 'mill'. Cartwright correctly alluded to it being one-tenth of a US cent. Perhaps the United States mint could help you out on this, but many years ago, according to my parents, a 'mill' was a form of coin, if not in fact a piece of currency, in common use in some parts of the United States. Like the pice in India, the 'mill' was used for extremely modest purchases. Needless to say, the 'mill' is no longer in general use here, and we wonder if the penny and the nickel may go the same way. The term 'mills per kilowatt-hour' is a common term of costs in conventional electric power accounting here. Perhaps this will help explain the word's origin.

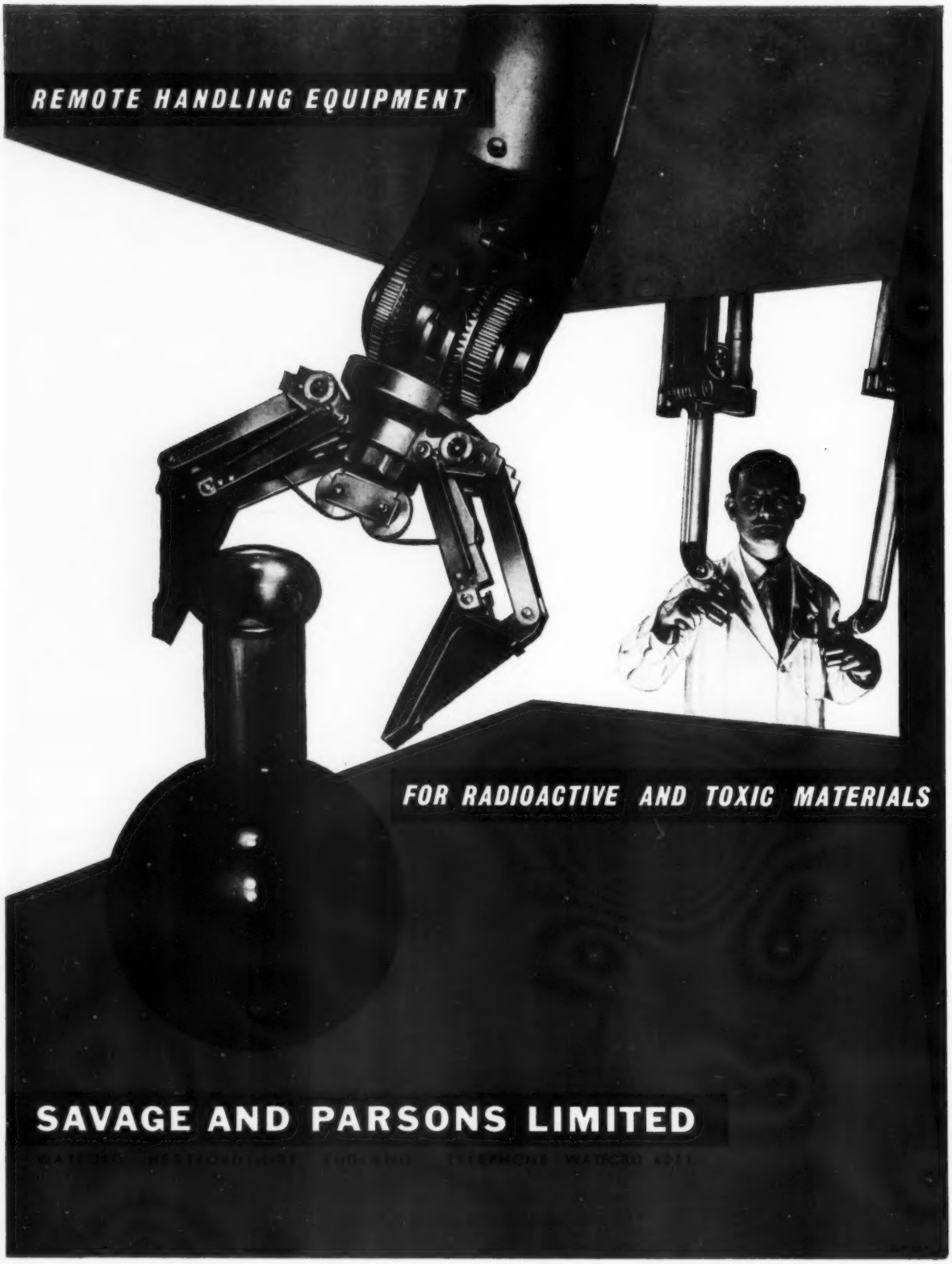
Atomic Industrial Forum Inc.
New York 22, N.Y. SAUL J. HARRIS

Advanced reactors

SIR: In reports of the James Forrest Lecture to the Institution of Civil Engineers in March, Sir John Cockcroft is mentioned as saying that the Atomic Energy Authority were working on a new reactor project known as the advanced gas-cooled reactor (AGR) which would work with fuel temperatures of about 600°C. In the past I have seen references to a very



Tick **No 69** on reply card for further details



SIR!

high temperature gas-cooled reactor which is being built—by General Electric, I think—for the AEA at their Winfrith Heath Station. Are these two reactors one and the same thing, if not, what is the difference?

Scunthorpe, Lincs. P. L. LLOYD-THOMAS

▶ *No, the two reactors are different and Sir John actually said so.* AGR *is to have fuel elements of uranium oxide sealed into beryllium cans but apart from this it will be generally similar to Calder Hall.* HTGR *on the other hand is for even higher temperatures* (700-800°C) *and will have all-ceramic elements incorporating both fuel (uranium and thorium) and moderator (graphite) sheathed in impervious ceramic material. A zero-energy* HTGR *is indeed being built at Winfrith Heath but so far no construction plans for* AGR *have been announced.* *Ed.*

String and sealing-wax

SIR: I was interested to read in last month's NUCLEAR POWER your previews of the two exhibitions—the Physical Society Exhibition and the Instruments, Electronics and Automation Exhibition—and it struck me how swiftly the former is changing its character. This feeling was reinforced when I visited the Horticultural Hall and I was horrified to find how near the show has become to a normal commercial exhibition. Until only a few years ago the Physical Society was fun. Instead of an elaborate stand, all you needed was a baize-covered table at which boffin types demonstrated their pet apparatus. Usually these worked when required, but even if they didn't everyone understood and anyway it was the idea that mattered. Now everything is slicked up and little is shown that is not finalized and productionized to the last degree and I feel this is a great pity. Before the IEA show started last year there was a definite need for a commercial instrument show and this was reflected in the change in the Physical Society. Now, however, the IEA does all that is needed in this direction and I feel it would be nice if the PS could go back to its nice old string-and-sealing-wax carefree ways.

London, NW3 L. R. STOREY

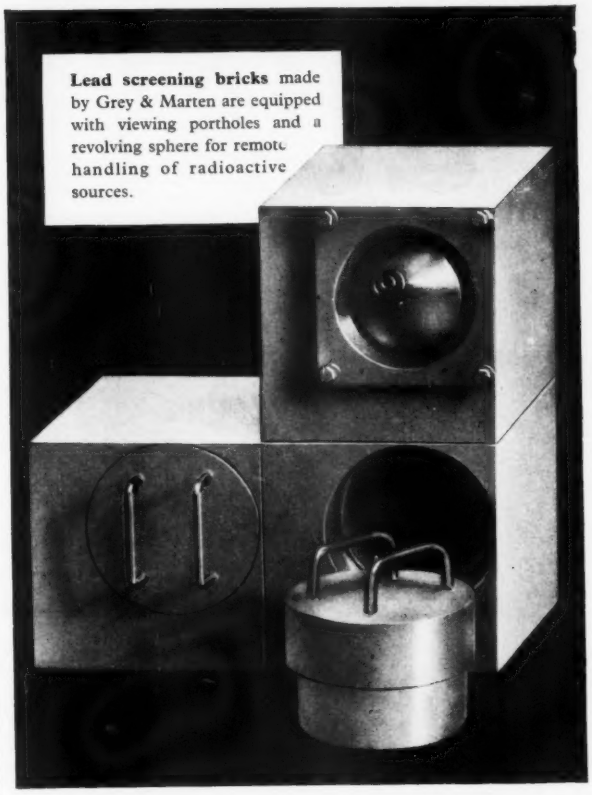
Back to school

SIR: Thanks for your letter (see *Sir*, March 1958). I can't understand why the tonne is now used when referring to deadweight tonnage of ships. To we old timers it is quite confusing, especially when so many new words are now in use in connection with nuclear physics and engineering. I had to go back to school again to catch up with the latest theory on nuclear physics and I am completing a post graduate course in nuclear engineering at the University of Pennsylvania. I took Physics in 1908-1909 under Prof Rutherford at the old Owens College, University of Manchester, little thinking then what he would eventually discover. I graduated as an external from the University of London in 1910 in mechanical engineering.

Sun Shipbuilding & Dry Dock Co., G. McCONECHY
Chester, Pennsylvania

▶ *The authors of this article* (Hinton *and* Moore, *N.P. January*, 1958) *only used 'tonne' in referring to weights of uranium: for deadweights they stick to 'ton'—meaning of course the British long ton of* 2240 *lb. Mr McConechy's letter shows indeed that it's never too late to learn.* *Ed.*

Tick **No 70** on reply card for further details



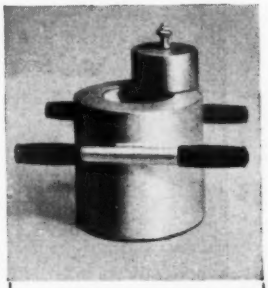
Lead screening bricks made by Grey & Marten are equipped with viewing portholes and a revolving sphere for remote handling of radioactive sources.

Ask Grey & Marten about lead shielding

(They've been handling lead for 125 years)

GREY & MARTEN are experts in lead. They've specialised in the manufacture of *all* kinds of lead castings, fabrications and fillings for more than a century. Interlocking Lead Bricks (in one, two and four-inch thicknesses), Lead Sphere Units (in two and four-inch bricks), Aperture and Viewing Bricks, Lead Pots and Isotope Carriers are all produced under the Grey & Marten name.

Consult Grey & Marten whenever you need screening against radioactivity.



Storage pot typical of those used in standard safes not already fitted with lead protection, affords economical storage for radio-active material.

GREY & MARTEN LTD

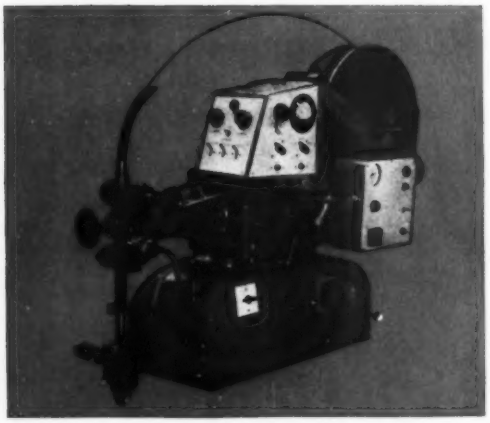
Established 1833

CITY LEAD WORKS, SOUTHWARK BRIDGE, S.E.1
and at Birmingham, Manchester and Ipswich

Tick **No 71** on reply card for further details

QUASI-ARC

special welding equipment for nuclear power plant construction



Self-propelled automatic welding machine specially designed for use with the FUSARC and FUSARC/CO_2 processes and used in the construction of nuclear power plant. The FUSARC/CO_2 process employs a specially developed flux-covered continuous electrode in conjunction with a carbon dioxide gas shield to produce high quality weld deposits at high welding speeds.

Macrograph of a weld made in 4½" plate in the horizontal-vertical position by the FUSARC/CO_2 process.

QUASI-ARC LIMITED offer a comprehensive range of welding processes, including the newly-developed patented FUSARC/CO_2 process, and a complete welding service to all industries. One aspect of this service is the design and manufacture of automatic welding equipment which is being used in the construction of nuclear power plants.

Here are examples of the specialised equipment Quasi-Arc has produced in this field:—

Complete manipulating equipment for the automatic welding at high deposition speeds of thick-walled spherical reactor vessels at the Bradwell power station—produced for Whessoe Limited. This equipment uses the UNIONMELT submerged arc multi-power tandem welding process, giving welding speeds 8-10 times as fast as manual welding.

Complete equipment, also incorporating multi-power tandem welding, for internal and external welding of giant cylindrical pressure vessels and heat exchangers at Hunterston power station. This equipment was produced for Motherwell Bridge and Engineering Company Limited (member of the GEC/Simon-Carves Atomic Energy Group), and comprises the largest high-lift boom ever made, large capacity traversing roller beds, and bogies for testing and stress relieving.

Large numbers of Quasi-Arc metal plate rectifiers—the most advanced form of welding power supply—are being used on atomic sites throughout the country, as well as rotary D.C. equipment and the well-known range of A.C. transformer sets. Quasi-Arc manual and automatic welding electrodes for nuclear plant construction include types designed for highly specialised applications.

Quasi-Arc are the pioneers of arc welding, with 45 years' experience to draw on—they are the natural choice of supplier for all equipment for work on nuclear energy contracts, for requirements ranging from manual electrodes to complete automatic welding installations.

For better welding

and friendly service

QUASI-ARC

QUASI-ARC LIMITED BILSTON • STAFFORDSHIRE

Nuclear Power
THE JOURNAL OF BRITISH NUCLEAR ENGINEERING
MAY 1958 VOLUME 3 NUMBER 25

Orders of Magnitude

We have come a long way in atomic energy since the days when it was an exclusive province of the technologist. Then, the only thing that mattered was possession of atomic weapons and when money was needed it was promptly voted by Parliament under some defence appropriation, with no questions asked. This, of course, still continues but in the matter of peaceful applications the City economists and financiers are now in effective control, subject of course to overriding Government financial policy. This is not as bad as it sounds because on the whole the City has adopted a very practical and enlightened attitude towards the subject.

This was reflected very clearly at the FBI conference at Eastbourne where one of the most eagerly discussed papers was one on financial and investment aspects of nuclear energy by Mr Cuthbertson of Lazard Brothers and Mr Brodrick, an economist with English Electric. This paper came in for quite a lot of lobby criticism—mainly on the grounds that its basic data were too shaky for any realistic prognostication—but this is really no argument for not attempting it. The authors in fact were at pains to point out that owing to the lack of hard data their financial calculations were to be taken as being no more than 'illustrative of orders of magnitude in the present state of knowledge.'

In general, Cuthbertson and Brodrick conclude that the current British programme is probably financially feasible but that the success or failure may well depend on the crucial factor of interest rates. On the matter of exports the position is even less easy to gauge. They estimate export orders rising from £13-18 million a year for the next two years, to £85-100 million for the period 1966-75, but as far as we can make out this ignores the vital fact that as exports of nuclear power plant grow, sales of conventional coal, oil and diesel generating plant must be expected to decline—at least after a period.

Economic studies such as that by Cuthbertson and Brodrick are of considerable value even at the moment, but they cannot form a secure basis for planning until more adequate basic data are made available. In this, the Atomic Energy Authority are largely to blame. Calder Hall, for example, has now been working for over 18 months and data on fuel and operating costs must surely be available. These have so far been withheld from publication on the grounds that from these could be worked out the probable production rate of plutonium. Just how important this really is, one doesn't know, but it is quite possible even now for anyone really determined and equipped with the necessary knowledge to work it out to a fair approximation. As a matter of fact, a rough shot at the figure can be made with practically no effort at all, since the French have disclosed that their G2 and G3 reactors at Marcoule —which are very nearly equivalent in thermal rating to Calder Hall—will produce 100 kg of plutonium a year.

Until 1960-61 the Atomic Energy Authority will be the only operators of nuclear power plant in this country and if we have to wait for the first CEGB stations before obtaining any hard figures on fuel costs the economists can hardly be blamed for speculating on what some people consider unreliable basic assumptions.

The construction of nuclear power stations has created a need for particularly large and powerful cranes and this is an aspect of crane building which has always been a special feature with Butters Bros.

Thus it is natural that from the very beginning a considerable number of

BUTTERS DERRICKS

have been engaged in this work

At Dounreay, shown above, a 30 ton and a 15 ton Derrick on high towers were employed, and Butters Derricks have been used, or are now in use, at Calder Hall, Chapel Cross, Hinkley Point, Berkeley and Bradwell.

In addition our Monotower Cranes are proving invaluable at Berkeley Nuclear Power Station where four 15 ton models are being used for erecting the reactors and general construction.

BUTTERS BROS. & CO. LTD., **MACLELLAN STREET, GLASGOW S.1**
AND AT LONDON, BIRMINGHAM & NEWCASTLE

Nuclear ships without turbines

A design study for a submarine tanker which will use a new method of converting heat from a nuclear reactor into power will be made during the next six months by Mitchell Engineering Ltd. Announcing this recently, Mr F. G. Mitchell, Chairman of the company, said that the propulsion system, which has been patented, will use steam to drive a shaft by direct means without the aid of turbines. He would give no further details but revealed that work has been going on for more than a year in five different factories. 'We hope to have the machinery assembled in a year and harness it to a small and light reactor which we are building for installation in the submarine,' he said. £100,000 has been set aside for the project. The submarine will probably be 50,000 to 60,000 tons weight and travel at a speed of up to 50 knots. It will need a crew of only five, Mr Mitchell thought, and he envisaged the possibility of ultimate radio control. The cost will be low compared with that of ordinary tankers.

Further results of the tests initiated by the company using submarine tanker models at the testing tanks of Saunders-Roe Ltd at Cowes were given by Mr W. A. Crago, director of the research, in the magazine *Impulse*, which is sponsored by Mitchell Engineering. Six models were made from laminated mahogany with contours exact to within a hundredth of an inch to analyse the resistance of submerged bodies, and it was found that the best shape for any given ship would depend on the proposed depth, size and cruising speed. 'One thing is quite clear already,' wrote Mr Crago. 'If in general transport speeds of 50 knots and upwards are required, the underwater tanker offers very considerable promise and merits close investigation of the engineering problems involved.' From his research he has prepared a graph which shows that for an 80,000-ton tanker the power required depends not only on depth of immersion but also on depth of water available. For a speed of 80 knots when deep immersed in deep water a power of about $3{\cdot}5 \times 10^6$ b.h.p. would be needed against over 7×10^6 b.h.p. for a surface ship. 'Of course,' he added, 'the idea of travelling at 80 knots and using such a tremendous horsepower is not practicable but the curves can be scaled down to smaller displacements with no loss of validity.'

First boiler up at Berkeley

The first of the sixteen 133-ton boilers has now been erected at the site of Berkeley nuclear power station. After fabrication in the site boiler shop was completed in April, the 70 ft long 17 ft 6 in. diameter vessel was moved on two bogies to its position adjoining No. 1 reactor house three hundred yards away. Lifting into the vertical position took three hours, and was accomplished by the use of a pair of gin poles carrying tackle powered by two winches while the base, which was carried on a tail bogie and rocker was held by a 130-ft boom 15-ton Lima crane. A steel girdle bearing against pads welded on to the outer surface of the vessel provided the necessary lifting points for the overhead tackle.

The first 133-ton boiler was lifted into position beside Berkeley No 1 reactor by tackle from two gin poles attached to a steel girdle butting against a welded pad. The skirt was supported by a tail bogie and rocker during lifting and restrained by a Lima mobile crane acting as a winch

Immediately after erection, work began on the surrounding structural steelwork, and the next step is to clean the boiler internally by shot blasting and carry out an air pressure test before tubing is started. The massed water tubes for the gas/water heat exchange are prefabricated into tube packs at the John Thompson Wolverhampton works and sent to the site in polythene wrapping for building up, unit by unit, inside the vessel and welding to pipework connexions.

Transport compromise Each boiler is made up from five cylindrical sections and two domed ends, which are completed as far as possible at Wolverhampton before being moved singly to Berkeley for welding together in the site boilershop, which can accommodate four boilers at a time. This arrangement is designed to eliminate transportation of excessive loads while reducing to a minimum the amount of work to be done on site. On arrival at site the sections were off-loaded on to turntables carried on rail tracks which run from external loading bays directly into position in the site boilershop. The sections were there brought together and welded by hand, the vessel being rotated on the turntables and the welding operation executed in the down-hand position from staging erected along the full length of the shop. At this stage the plate skirt was welded on and all welds X-rayed.

Stress relief Upon completion of welding external induction heating coils were used for stress relief in the area of the

seams and the vessel was hydraulically tested to 240 psi. The complete boiler, still on its turntables, was then rolled out on to the external loading bay, where it was placed on road bogies for movement to its foundations by the reactor house.

Electronics sell £M60 abroad

Exports of electronic equipment from Britain last year, excluding 'entertainment' items, reached no less than £60 million. Over £M3 of this went to the dollar markets and this represents double what they were two years ago. These are the first authoritative figures ever published and they were obtained from the Board of Trade in time to be quoted by Mr E. W. Semmens, the chairman, at the preview of the Instruments, Electronics and Automation exhibition in London on April 15. Mr Semmens, who is chairman of Nalder Brothers & Thompson Ltd, said the exhibition—the second to be held—had grown out of all recognition. Floor space was one-third more and the 260 exhibitors included 60 new ones. This year there is a fair representation of overseas firms and Mr Semmens hoped that even more would come to the next IEA.

Although not designed as a nuclear energy show, or even with any avowed inclination this way, many of the exhibitors were showing equipment which has nuclear applications. If indeed the exhibition had any slant one way or the other it was towards control systems and a great many firms are now not content to provide apparatus merely for indicating or recording physical quantities: they are more and more going towards control elements. The exhibition was officially opened on April 16 by Sir David Eccles, President of the Board of Trade.

A conference was run concurrently with the exhibition and on April 17 Dr S. Kaufman of AEI, Aldermaston, surveyed thermonuclear developments achieved with SCEPTRE III. The goal at Aldermaston, he said, is 10 million degrees. One difficulty still unresolved is the sparking which occurs across segments of the torus and between the plasma and the walls. If this can be eliminated the temperatures would be a bit higher.

Progress at Hinkley

Work on the concrete foundations of No 1 reactor for the 500 MW power station at Hinkley Point was completed in mid-April and construction of the 90 ft high 75 ft diameter biological shields is under way. To achieve this, 175,000 cubic yards of rock and earth have been moved in just over three months in spite of winter conditions. Good progress is being made on the foundations for the circulator houses and steam raising units, and excavation for the turbine house has begun. Following preliminary investigation by divers for work on the cooling water system building is now going forward.

Workshop facilities for teams from English Electric and Babcock & Wilcox have been completed and a small township now exists adjacent to the site capable of housing 400 men. At the river port of Combwich, near Cannington the construction of a new wharf is so far advanced that it is expected to receive its first shipments of plant and equipment for the site by July.

New reactor at Harwell

A new homogeneous research reactor is now operating at Harwell, the Atomic Energy Authority announced recently. It is known as HAZEL (homogeneous assembly zero energy), and uses enriched uranium fuel in the form of a salt of uranium—uranyl fluoride—which is dissolved in the heavy water used as a moderator. The core is a stainless steel cylinder, seven feet high by two feet in diameter, surrounded by a graphite reflector.

The fuel solution is pumped into the cylinder from two storage vessels. The system is controlled by adjusting the level of the solution in the core and by moving a vertical neutron-absorbing cadmium plate into the gap between the cylinder and the graphite reflector. Two cadmium plates, similar to the control device are used as shut-off rods and two additional shut-off rods can be dropped vertically into the fuel solution in the reactor vessel. The reactor will be operated at a power of less than a watt and cooling is not necessary.

HAZEL is the second homogeneous reactor to be built at Harwell and will be used to obtain basic nuclear information say the Authority. The first system —ZETR (zero energy thermal reactor)—was used to study solutions of nuclear fuel in ordinary water.

More Fleck changes in IG

The Industrial Group of the Atomic Energy Authority has announced the appointment of Dr J. M. Hill as deputy director of operations (technical) at Risley. Dr Hill was formerly deputy director of technical policy. Mr G. R. Howells, MBE, previously chemical engineering adviser at Risley, becomes works general manager at Chapel Cross Works. Other appointments, some of them designed to implement the recommendations of the Fleck Committee on the Windscale accident, are that of Mr H. Cartwright, MBE, as deputy director of the Industrial Power branch at Risley—he was assistant director (experimental reactors)—Mr W. R. A. Taylor, who moves from his position of works manager at Capenhurst to deputy works general manager, and Mr C. R. Tottle who becomes deputy director (reactors) at Dounreay. Mr D. R. Mackey, previously head of laboratories at Windscale has taken up the position of deputy works general manager (chemical plants) there.

New reactors soon

Partnership between the Atomic Energy Authority and industry was the main theme of AEA chairman Sir Edwin Plowden's opening address to the two-day conference on nuclear power held by the Federation of British Industries at Eastbourne on April 10-11. Such co-operation was essential because the development of a completely new reactor system was beyond the financial and man-power resources of even the largest industrial firm. Sir Edwin declared that this might involve 1000 man-years of professional effort together with adequate technical support. A typical scheme might be as follows: 1 year's feasibility study involving 50-100 scientists and engineers, 1 year's design study with 100-150 men, 2 years to build a reactor experiment—needing 150 scientists, 3 years to construct the prototype power reactor—250 scientists. This was a very costly business indeed and the Authority is spending about £10,000 a year on each professional scientist or technician, including his supporting staff.

PLOWDEN
Firms can't go it alone

He considered that there were now probably enough industrial reactor firms in the field and thought that the five big groups included between them practically every firm in the power station business. There was however a great scope for specialist ancillary firms.

Sir Edwin disclosed that arrangements had recently been made to have regular

meetings with members of the chemical engineering industry to assist them in entering the field and he said that soon the Authority hoped to be in a position to invite firms to assist on new reactor systems. He welcomed initiative from industry and promised to let it in at as early a stage as possible. Some of the other speeches are reported elsewhere in this issue.

DIDO aids Stonehenge restoration

Sodium-24 from the DIDO reactor at Harwell was used recently at Stonehenge for the X-ray of a 45 ton stone to check the depth of a crack before re-erection as part of the Ministry of Works restoration scheme. The 3 in. cylinder of sodium was transported from Harwell in a 16 cwt. lead container which was lifted by a crane mounted on the back of the Harwell lorry, and lowered into position near a channel cut under the 4 ft 6 in. stone. The sodium can was then pulled halfway through the channel by tongs and three square yards of fast X-ray film, suitably wrapped in waterproof covering, were fixed to the top of the stone covering the crack. Thirty-six hours later the film and sodium were removed, and after development at Harwell the film showed that cracks in the stone did not extend right through, so that lifting could proceed. The X-ray work was done under the direction of Mr R. Derbyshire, a senior experimental officer of Harwell. The sodium-24 was made by exposing 24 g of sodium carbonate to neutron bombardment in DIDO.

Businessmen to study isotope uses

A course on radioisotopes designed for senior executives in industry will be held at the Harwell Isotope School from September 23 to 26. A similar course, for members of the Institute of Directors only, began on April 15 and another will start July 8. The course consists of lectures on the elementary principles of work with radioactive isotopes with a strong emphasis on their application as tools in industry and research. The lectures will be given in as non-technical a manner as possible and will be supplemented by visits to a reactor, to the laboratories of the Isotope Division at Harwell and the Wantage Radiation Laboratory. The lectures and demonstrations will be given in the Cockcroft Hall at Harwell.

Year's delay in nuclear plans

The completion of the nuclear power programme for 1965 described in the appendix to last year's White Paper is to be postponed a year and a higher proportion of new generating capacity installed during the period will be in the form of coal-fired stations, at a lower capital cost. This is stated by a White Paper published on April 15. With the level of expenditure approved for 1958-59 work on new power stations, previously planned for the next twenty-four months will be spread over about twenty-six. Actual capital expenditure on fixed assets in 1958-9 approved for the coal, gas and electricity industries is £M436—an increase of £M5 over the estimates for 1957-8. The share of the electricity industry in England and Wales is increased slightly, and gas and coal expenditure is to be reduced. Money spent on nuclear stations goes up by £M16 from the previous £M21, and conventional station building is to cost £M90 against £M100. Expenditure in 1957-8 on nuclear power stations represented continuing work on Berkeley and Bradwell, and the beginning of work on Hinkley Point station. On the distribution side, the boards should still be able to achieve their programme of connecting 85 pct of all farms in England and Wales by 1963.

Industry urged to tread softly

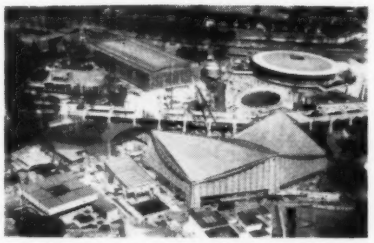
The Central Electricity Generating Board expects to place orders for only two nuclear and two main conventional power stations a year in future compared with the ten or more stations ordered each year in the past. The reason is the increasing output of individual stations. Sir Christopher Hinton, revealing this in a speech on April 15 to the Electrical Industries Club in London, expressed the hope that in view of these smaller number of larger parcels, the industry will organize itself so as to avoid the difficulties now experienced by the aircraft industry. Another difficulty in this country is that the load factor of the generating stations is still only 46 pct, and he thought that it is not well enough known that many power stations are idle from one year to another, waiting to supply the peak load when necessary. The cost of electricity generated by 50 such power stations with the lowest efficiency is 1s 9d a unit.

BELGIUM

UK ready on time

Over 100,000 people visited the Brussels Universal and International Exhibition on April 17 after the official opening by King Baudouin. The exhibition, covering 500 acres with contributions from 42 nations and 10 international organizations, will run for six months. In spite of high pressure working many countries have not quite completed their displays and the UK was congratulated on being one of the few exhibitors ready on time. The most dramatic structure is the 360 ft high Atomium consisting of nine 60 ft diameter aluminium clad spheres, seven of which hold displays of nuclear apparatus. Most costly of the national buildings is the Russian exhibit which at £M18 is three times more expensive than the American. Highlight of the Soviet display is a life size model of Sputnik II.

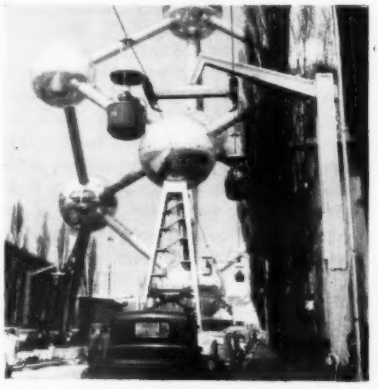
World advances in pure science during the past 25 years are illustrated in the International Science Hall which was



Behind the elevated carriageway the circular US building is separated from the Russian pavilion on its left by the Arab countries pavilion. The Canadian building lies on the left of the Russian. In the foreground is the unusual structure designed for Philips Electronics by Le Corbusier

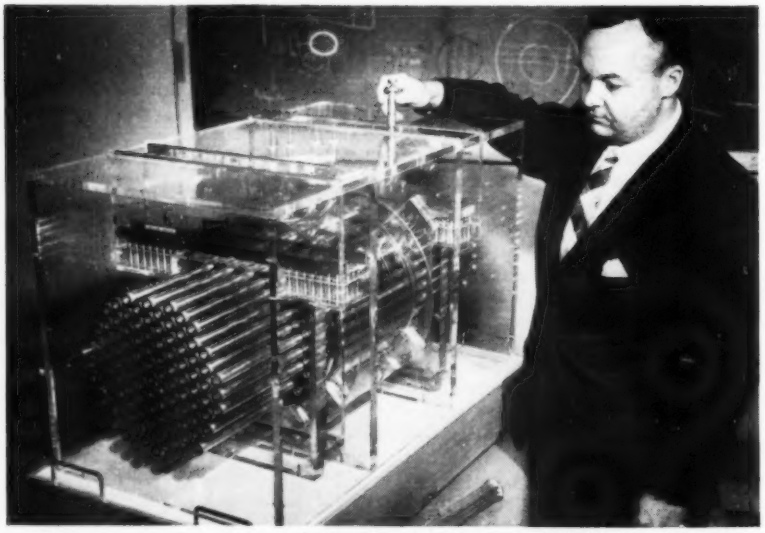
provided by Belgium. It includes exhibits under four main headings—the atom, the molecule, the crystal and the living cell. The 40 British exhibits include a model of the Cockcroft-Walton laboratory in which the nucleus was first split. The US displays concentrate on the recent discovery of the free neutrino and work on anti-matter.

The British buildings at the exhibition cover about 5 acres and were built by Richard Costain Ltd. The industries pavilion is one of the biggest to be



An overhead railway with bucket seats has been built for the use of spectators. Behind it is the 360 ft high Atomium

financed by private firms. The 35 ft high glass walls surround a floor area of 60,000 sq ft containing 60 stands from 500 firms. The largest section is that of the electricity industry covering conventional and nuclear production of electricity—Britain is at present the



HPTR—new reactor design of Canadian Westinghouse (Worldview, March)—envisages fuelling by small clusters of Zircaloy tubes containing natural uranium oxide. Surrounding the fuel rods will be cooling water under pressure in horizontal tubes which are to be insulated to keep down the temperature of the surrounding heavy water moderator. Mr V. Mason, manager of the Atomic Energy Division states that it could produce electrical power at a cost of only 6·5 to 12 mills per unit

world's biggest exporter of heavy electrical equipment. Prominent in the government display, which cost about £M½, are the first model of ZETA to be shown to the public and a 30 ft wide diorama of the Dounreay station.

CANADA

NRU refuels in action

The NRU reactor at Chalk River has been refuelled while in operation—the first time this has been done anywhere. Uranium fuel rods were successfully changed in the first fully operational test of the fuelling machine since the reactor went critical last November.

The fuelling machine, which like all other components except the heat exchangers was designed and built in Canada, is 43 ft high and weighs 240 tons. It travels on rails and can be positioned within one hundredth of an inch over the top of the reactor. Much of its weight is due to the heavy shielding required to protect engineers and operating personnel. The rods must be cooled continuously while they are being removed, thus adding to the complexity of the fuelling machine, and seventeen pumps handle the cooling system. Heavy water cools the rod, ordinary water cools the heavy water, and then a refrigeration system cools the ordinary water.

The machine, carrying a fresh uranium rod within its tower-like structure, moves over the top of the reactor, pulls out a used rod, puts in a new one, and then moves across a bridge to a point over a water-filled canal. The highly radioactive rod is lowered onto a carriage in the canal and is then moved into a large water-filled tank where it is stored for six months.

FRANCE

EL3 now among world's largest

The reactor EL3 at the Saclay centre of nuclear research in France has developed a power of 10 tMW. Its neutron flux of 8 x 10^{13} n/cm²/sec places it among the largest research reactors in the world—the third after the American MTR and the English DIDO, not counting any in Russia. The neutron flux of EL3 is ten times as great as the pile EL2 which has been functioning since 1952, and it will be used to produce radioisotopes which the older pile cannot make, in addition to furthering research generally. The physicists at the centre carried out six months of experiments at low power to get used to the operation before allowing it to exceed the neutron flux record of EL2 last December.

ITALY

ENSI reactor choice in autumn?

A decision on who is to provide the 150 eMW reactor for the ENSI (Energia Nucleare Sud Italia) project at Garigliano is unlikely to be made before the autumn, although tenders from the 3 English, 4 US and one each Canadian and French groups must be in by April 30. This results partly from the delay in Italian parliament ratification of the UK/Italy agreement (*Worldview*, February) for fuel supplies and reprocessing, which cannot now take place before the next legislative session. 'Until ratification,' Professor Ippolito, general secretary of CNRN — Comitato Nucleare Ricerche Nazionale—said recently, 'the English firms invited to tender do not have the guarantee of the British Government for providing the fuel.' CNRN, in cooperation with the world bank will have to decide which is the best type of reactor to use, and the UKAEA and USAEC have agreed to provide nuclear engineering consultants for technical review of natural and enriched uranium tenders respectively.

UNITED STATES

Reactor setback at Oak Ridge

After being run up to a power of 5tMW the homogeneous aqueous reactor HRE2 at Oak Ridge was shut down on April 16 when it was discovered that the core solution was escaping into the blanket heavy water system, announces a report from the laboratory.

The fuel is a solution of uranyl sulphate, highly enriched in U-235, in heavy water and the reactor is a two-zone forced circulation type operating on the thorium/U-233 breeding cycle. Core is enclosed by a 32 in. inner diameter Zircaloy sphere $\frac{5}{16}$ in. thick inside a 60 in. diameter 4·4 in. thick stainless steel pressure vessel. It was designed for a feasibility study of homogeneous aqueous reactors for power and is virtually a full scale prototype power reactor. It went critical in January, and was operated at low power for three months before being allowed to go up to 5 tMW. It had been intended to run it on power for six months or more to establish reliability of operation and the next phase was expected to involve a change to a suspension of thorium oxide in heavy water as a blanket. Causes of the failure of the core container are being investigated.

No need for haste

No reactor is known or thought of which gives firm promise of producing energy in the US at a cost equal to or less than that produced by conventional fuels, according to Philip Sporn, American Gas and Electricity Company President. He said recently that even an optimistic estimate would show that a nuclear plant generating at perhaps 9¾ mills per unit might be realized by 1966 as compared to conventional power plant of 200 MW size at about 4¾ mills per unit in the most favourable fuel areas and 7¾ mills in the least. The cost disadvantages for nuclear plant, he thought, are simply too large to be assumed by responsible authorities. In any case the attainment of ultimately competitive power by reactor designs which could be completed by 1965 or 1966 is uncertain —there are too many technical unknowns in the picture. Adequate conventional

fuel is available for the planned installation of over 100,000 MW of new capacity by 1965 and no large portion is likely to be based on nuclear energy. On the other hand, he said that 20,000 MW of the extra 200,000 MW of capacity expected to be installed between 1965 and 1975 might well be atomic.

New high for particle energy

The physics department of the High Voltage Engineering Corporation has measured a nine million volt proton beam from a tandem Van de Graaff particle accelerator. The successful operation of this prototype design employing the charge exchange method marks the highest particle energy reached for precise binding energy research, claims the corporation. The breakthrough will allow physicists to explore atomic binding forces in nuclei of heavier elements. The accelerator is to be delivered to Atomic Energy of Canada Ltd.

Anti-neutron destruction viewed

Scientists at the University of California's radiation laboratory have photographed the annihilation of the anti-neutron. Dr Emilio Segrè, giving a lecture in New York on his Californian research, said that an anti-proton was tracked by photographic emulsion exposed in the beam of a Bevatron. It hit a proton and generated a neutron and an auti-neutron. The anti-neutron continued until it collided with a nucleon. Both were annihilated and turned into energy. 'Even in the blast of the hydrogen bomb,' commented Dr. Segrè, 'man has not been able to effect so neat and efficient a change of mass into energy.' He claimed that the experiment 'offered the newest evidence of the great efficiency with which matter and anti-matter destroy each other.'

INTERNATIONAL

IAEA team visits Russia

Officials of the International Atomic Energy Agency returned to headquarters on April 16 after making a week's study tour of the USSR at the invitation of the Soviet government. Pavel Winkler, chairman of the board of governors, Sterling Cole, director general, and one of the deputy directors general, Dr Paul R. Jolles, visited national and international atomic installations in Moscow, Dubna, and Leningrad. They arrived in Moscow on April 8 after a one-day stop in Prague. The head of the Soviet atomic energy committee is reported to have paid tribute to the atmosphere of cordiality and cooperation existing during the Vienna meetings of the IAEA.

WORLDBRIEFS

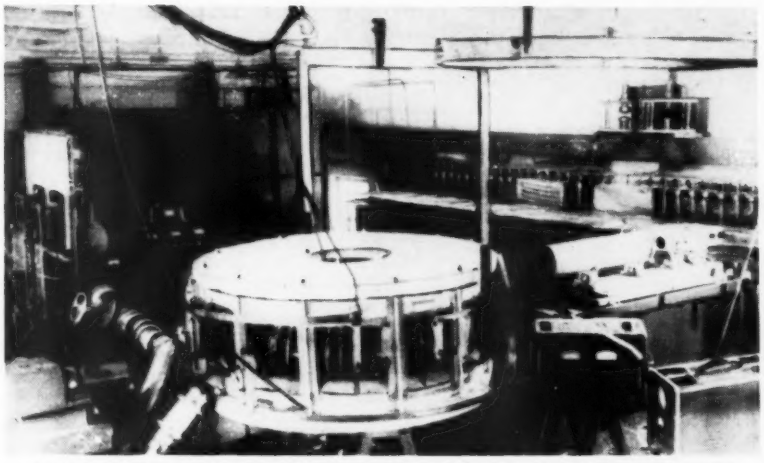
A month's course in protection against **radiation** has been given at the Centre for Nuclear Studies at Saclay in France. Organized at the request of the World Health Oganization for doctors from fifteen countries, the course included a detailed study of methods of individual and collective security.

A new 20-30 MW research reactor at Oak Ridge National Laboratory has gone **critical.** The ORR—Oak Ridge Research reactor—uses enriched uranium plate-type elements of uranium-aluminium alloy clad with aluminium. The core is beryllium reflected and moderated and cooled with demineralized water. It is a modification of Oak Ridge's Materials Testing Reactor, and will be used for research on effects of radiation on reactor materials.

At a meeting of top-level scientists and engineers, including Sir John Cockcroft, at the European Nuclear Energy Agency of the **OEEC** a group of specialists was instructed to prepare a report on the proposed joint experimental reactor in the UK. It was also agreed that the countries interested in joint running of the Norwegian boiling water reactor at Halden would hold a meeting in Oslo for final recommendation on its operation.

The experimental boiling water reactor —EBWR—of **Argonne** National Laboratory in the US has been successfully operated at a power level of 62 tMW. This is more than treble the original design level.

Theme of the Board of Trade exhibit at the **Hanover** trade fair opening April 27 will be UK progress in nuclear energy.



A thermonuclear device at the USSR Academy of Sciences Atomic Energy Institute has been described as 'one of the earlier toroidal chambers' but no details of its principle of operation have been released

Several hundred industrial leaders and scientists from forty different countries are to meet in Harrogate in June for the 1958 assembly of the International Organization for **Standardization**—ISO. It will be the first time the assembly has been held in Britain. The fifteen specialized technical committees will include one on nuclear energy.

Two-week **courses** on nuclear electronic instruments will be run in future at the Borough Polytechnic in London instead of at AERE Harwell. The first will be held in July and further information may be obtained from the secretary. Another new course is in applied physics with specialization in applied nuclear physics leading to the Diploma in Technology which is the same standard as an Honours Degree.

The Australian Atomic Energy research station at Lucas Heights, **Sydney** was officially opened on April 18. The research reactor—HIFAR—is a 10 MW DIDO type.

Atomic Energy of **Canada** Ltd has set up a nuclear plant division for directing and coordinating the NPD project and the development programme for a 200 MW plant. It is reckoned that 3½-4 years will be required for the development work, most of which will be undertaken by Canadian manufacturers.

Members of the Danish Association for Industrial Development of Atomic Energy—**Danatom**—now include four shipping companies and twenty-four industrial enterprises. It is expecting to start initial work soon on study prospects for an atomic power station and a ship reactor plant.

NUCLEAR POWER WELDING SYMPOSIUM

Introduction by Dr R. Weck

Director, British Welding Research Association

Without welding, the peaceful application of atomic energy would have remained a physicist's dream. No other method of joining would have solved the containment problem. The fuel cans, pipelines and reactor vessels and all other containers which form such vital parts of a nuclear power station have to be fabricated to exactingly high standards of reliability, and only a scientific joining technology, soundly based on research, made this possible.

The fabrication of all these containers went well beyond past experience. Extrapolation from past experience was successful because the fundamental scientific principles underlying past experience had been firmly established. Welding research and development which had been going on for years with quite different ends in view at a time when no one had even thought of a fuel element or a reactor vessel, had produced results which could be immediately applied to problems in nuclear engineering. Thus, when a method for sealing *Magnox* fuel cans was needed, it was readily at hand. Only recently the problem of sealing a thermocouple into a fuel element was solved by resistance welding in the laboratories of the British Welding Research Association.

Whatever direction future developments in reactor design may take, welding problems will undoubtedly influence decisions. The efficiency of the gas-cooled graphite-moderated reactor can only be increased by using a different canning material, which will have to be welded. Reactor vessels will have to operate at higher pressures and temperatures, and the problem of welding thick alloy steels will loom large. Problems in the welding of zirconium and stainless steel have to be considered for sodium-cooled graphite reactors, and the problem of welding a pressure vessel 12 ft diameter and perhaps 9 in. thick will have to be solved for the pressurized water reactor.

In the hands of the uninformed, welding can be a menace. Knowledge in this field is as indispensable to the engineer today as is knowledge in thermodynamics or strength of materials which have always been part of his technical education. Yet little or nothing is done to provide this indispensable knowledge in our technical education. As the atomic power programme is getting under way, the lack of engineers who have received systematic and scientific instruction in this vital field has become a very serious problem, and still scarcely anything is done to rectify this deficiency in our engineering education. The School of Welding Technology of the Institute of Welding is practically the only attempt to alleviate this situation. Whilst this initiative is to be welcomed, and deserves the strongest support from industry, it is nevertheless, for present conditions, totally inadequate. With the puny financial resources at the disposal of the Institute of Welding, it cannot be expanded to what is required. If this problem is not tackled vigorously by joint action of the Government and industry, there may be serious repercussions on the entire atomic power programme, as indeed in other equally important industries.

This symposium is to be warmly welcomed, because it will do much to draw attention to the vital part welding plays in nuclear power technology. One of the reasons why so far we have failed to make proper provision for systematic and scientific education and training in this field, is that its importance has remained unrecognized among those who are responsible for our educational policy. In presenting this special issue, NUCLEAR POWER is rendering a great service to all those who are concerned with research and the dissemination of knowledge in this field, without which further progress in nuclear power is impossible.

THE CONTRIBUTORS

1

I. H. Hogg *of Risley surveys the special problems of welding in nuclear energy plants and the techniques used*

2

Dr H. Harris, *Babcock & Wilcox, describes the method of fabricating pressure vessels for nuclear reactors*

3

P. K. Richards *of John Thompson Water Tube Boilers covers heat exchanger manufacture*

4

N. T. Burgess *Aluminium Development Association, describes welding of aluminium and its alloys to nuclear energy standards*

5

I. H. Morrison and A. F. Taylor, *at Springfields do the same for magnesium alloys*

6

Dr D. R. Harries and J. G. Purchas, *Harwell, describe methods of welding uranium, beryllium, zirconium and niobium*

7

J. A. McWilliam, *Firth-Vickers Stainless Steels, writes on the fabrication of corrosion and heat-resisting steels*

8

F. S. Dickinson *of Risley deals with non-destructive testing methods used in routine operations on nuclear plant*

9

NUCLEAR POWER *has compiled a buyers guide to equipment used in the welding industry*

Special problems in nuclear energy

I. H. HOGG, BSc, AMIMechE, AMIEE

UKAEA, Industrial Group, Risley

IT IS CLEAR from details which have been published on particular applications that welding has played a key role in the development of atomic energy, and it is worthwhile considering the aspects which distinguish the use of this process in the nuclear field from its use in the more conventional industries. These aspects can be considered under four main headings :

1. extremely high quality of welding and the inspection methods necessary to ensure this quality
2. accuracy of assembly of large fabrications
3. welding under radioactive conditions
4. the welding of unusual materials in quantity and/or large assemblies.

Quality of welding

The special problem encountered in the production of nuclear material e.g. U-235 and plutonium, and the operation of reactors, is the toxicity and/or radioactivity of the materials which have to be handled. This means that leakage cannot be tolerated, and in many cases maintenance during the life of the plant is extremely difficult, if not impossible. These facts have led to the very wide adoption of welding and the demand for the highest possible quality. A few examples will serve to illustrate this point.

In the production of plutonium at Dounreay it is necessary to pass the irradiated material through a chemical separation process to separate the plutonium from the uranium and fission products. The plant handles extremely corrosive radioactive materials and maintenance is almost impossible. Welding was used throughout and all welds below the liquor level were inspected by radiography. In the case of the vessels which, like the rest of the plant, were made from 18/13/1 stainless steel, metallic arc welding was used and the acceptance standard used in the X-ray inspection was extremely high, the only acceptable faults being very small isolated gas pores. To ensure that no faults were missed an X-ray technique employing fine grain film and lead screens was used and the welds were ground flush on both sides of the plate. This high standard applied to both small shop-welded process vessels and large site-welded effluent storage tanks.

The joining of the many miles of pipes used in this plant presented a difficult problem as the requirement was for a 100 pct sound weld with a smooth penetration bead so that there was no possibility of entrapment of active and/or corrosive material or the setting up of corrosion at this point. Consideration was given to the various available methods of welding pipes but at this time none of them gave the desired result and a special technique had to be developed in which the root run was made by fusing with the argon-arc process, with a backing of argon gas inside the pipe. Where possible these welds were inspected by radiography, but owing to the cramped nature of the work in the building it was necessary to use iridium-192 sources for the majority of the welds. A special technique was developed employing small sources (1 mm dia by 2 mm long and 2 mm dia by 2 mm long) which gave good definition. At one stage during construction one thousand gamma radiographs per week were being produced. Typical cramped conditions are illustrated in fig 1.

Another example of the high quality required is the gaseous diffusion plant at Capenhurst, used to concentrate the U-235 isotope. This plant deals with extremely corrosive gases and forms the largest vacuum system in Western Europe as the whole plant works under vacuum. It employs approximately 100 miles of pipework, and wherever possible welding is used in this construction. The vacuum standard required is so tight that if the plant were evacuated and isolated it would take a considerable number of years for the pressure to approach atmospheric. To enable

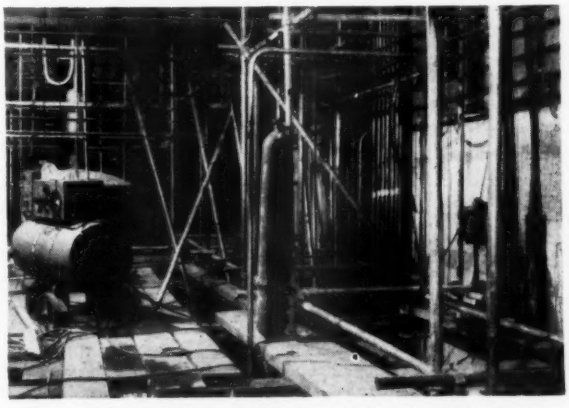


Fig 1 Congestion of pipes at Windscale made X-ray inspection impractical and gamma radiography was used

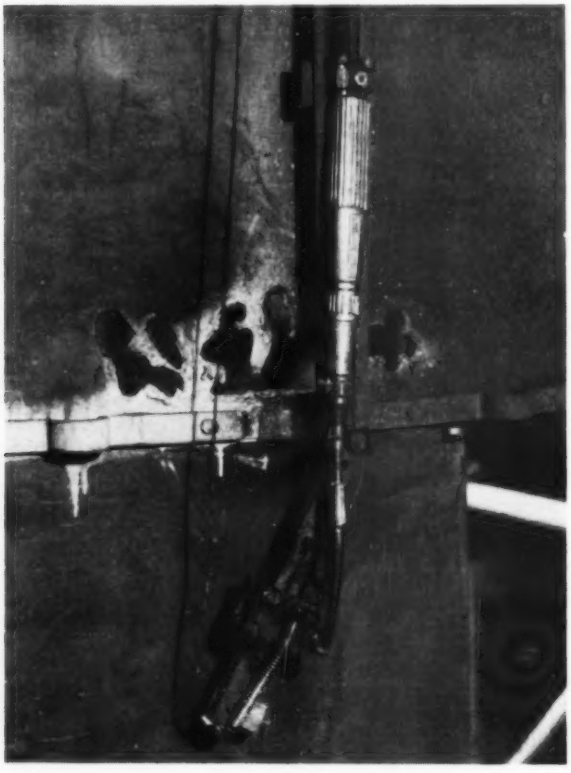
this high standard to be obtained both the components comprising the plant, and finally the whole plant, were vacuum tested and extremely satisfactory results were obtained.

In the gas-cooled type of reactor exemplified by Calder Hall it is necessary to contain the fuel in a sealed can, both to prevent the oxidization of the uranium by the coolant gas and to prevent the escape of fission products which would contaminate the coolant circuit and heat exchangers. In Calder, magnesium alloy cans are used, and are sealed by edge welding caps at each end by automatic argon-arc welding. The can is filled with helium and the soundness of the weld is checked by using a mass spectrometer to detect the slightest leak. The weld is also radiographed to check for inclusions, usually tungsten.

The pressure vessels used in these reactors are built to Lloyd's Class I standards and, whilst this in itself presents

Fig 2 In welding the charge/discharge tubes at Calder very careful setting was required to keep within the close tolerances laid down

Fig 3 One of the problems at Windscale was welding loose baffle plates in the coolant circuit. A mock-up was used for operational practice and this is the mounting used for the cutting torch



no great difficulty, the novelty lies in the size of vessel (ranging from 38 ft dia by 70 ft high for Calder, to 70 ft dia sphere for Hunterston) and the fact that the welding is done under site conditions. At present the maximum thickness is limited to 3 in., but this may well increase and the problem of both welding and inspection of these thick welds may raise considerable problems.

Where liquid metal is used as a coolant, as in the fast reactor, the welding has to be of the same high standard as that used in the active chemical separation plant already described, and in fact the technique for the welding of the pipes in the primary heat exchanger circuit is identical. These welds are all X-rayed and an extremely high standard is demanded.

Accuracy of assembly

Fundamentally the gas-cooled graphite-moderated reactor consists of a graphite core with channels of fuel elements contained in a pressure vessel and with means to circulate the coolant gas and abstract the heat. Some means has to be provided for charging and discharging the fuel elements and for this to be possible accurate alignment of channels in the graphite and the orifices in the pressure vessel are essential. In the case of Calder the accuracy specified for the pressure vessel was that the axis of the vessel should at all times remain vertical and should not depart from the vertical by more than $\frac{1}{4}$ in. in 30 ft. The top of the vessel was not to be displaced angularly about its vertical axis by an amount exceeding $\frac{1}{4}$ in. measured at the edge of the dome. The circularity of the plate was to be $\pm\frac{1}{2}$ in. on the radius.

The charge/discharge tubes which are welded into the top dome (fig 2) were welded to the following tolerances: the centre of the bottom end of the charge tube had to lie within a circle of $\frac{1}{8}$ in. diameter whose centre was the true position; the misalignment from the point achieved above the centre of the top flange could not exceed $\frac{1}{16}$ in. (the length of tube varies from 12 ft 3 in. to 17 ft 2 in.); the level of the top flanges had to be within $\frac{1}{8}$ in. from the fixed height.

It will be appreciated from these close limits that very careful setting and welding is required. In the case of the fast reactor cooled by liquid metal the core is much smaller but is contained in an extremely complicated stainless steel vessel which is built to close limits. In the fabrication of this vessel sections up to $4\frac{1}{4}$ in. thick had to be welded, levelled, and machined to half the original weight to form suitable sections for further welding, and careful stress relief had to be carried out at intermediate stages. Very close tolerances were required on the top of the vessel to accommodate the charge and discharge mechanism and the ovality had to be less than 0·1 pct, alignment within 0·3 pct and almost perfect concentricity.

In the case of the Dounreay fast reactor the vessel could be shop fabricated and therefore, if necessary, finally machined after fabrication. But this vessel approached the maximum size which could be transported to the particular site in one piece; any great increase in size might lead to site assembly and the problem of welding premachined parts to a very high accuracy might have to be faced.

Welding under radioactive conditions

One problem that will have to be faced as nuclear plants and power stations grow older is that of maintenance and possible repair. There are two possible ways of enabling the worker to operate under active conditions: by protection, using either shielding material or distance, and by reducing the time of exposure.

The first method requires the use of some type of mani-

pulator. These are widely used in the nuclear field, and there are few jobs which cannot be done with their aid, but they are usually built in to special 'caves' with everything designed for their use. Remote welding may have to be carried out under all types of circumstances and considerable ingenuity will be called for. A job of this nature has been done on the Windscale piles where difficulty was experienced in the working loose of baffle plates in the coolant circuit. Access to these plates could only be obtained through 4 in. diameter holes in the shielding and by using an introscope through one hole, the cutting and/or welding torch through another, and a light through a third, a considerable amount of cutting and welding was carried out. In this type of job it is essential to try out the drill under inactive conditions and a mockup of the job

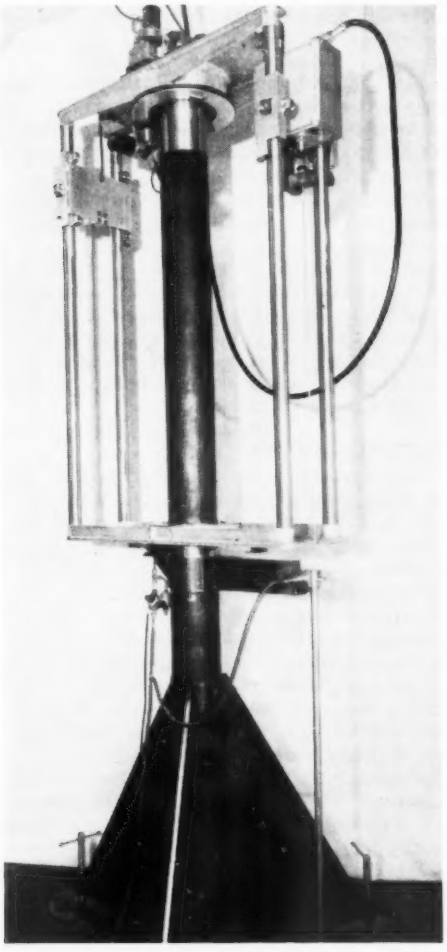


Fig 4 This recently developed television camera and introscope arrangement (top right) can be inserted down a $\frac{1}{4}$ in. diameter tube

with tubes being used to simulate the holes was built so that operators could be trained. Figure 3 shows the simple but effective mounting of the cutting torch used for this work.

Difficulty of gaining access to this part of the reactor emphasizes the need for the question of access to be considered at the design stage, as it is now becoming clearer that much more work of this nature can be done than had previously been thought.

Considerable strides have been made in the development of special television cameras to assist in viewing, and one of the latest developments, shown in figure 4, can be inserted down a tube as small as $\frac{1}{4}$ in. diameter. The camera with the introscope attached can be seen at the top of the right hand tubular guide.

The alternative method of enabling the operator to work under radioactive conditions—by restricting the time of exposure—has been widely used. One of the most spectacular jobs of this nature was carried out in Canada when an accident occurred in NRX, necessitating the removal of the whole core. The operators were trained in the operation they had to perform and were then sent on to the job to perform part or whole of a particular operation. The activity in some parts was such that the time for which they could work was as short as five minutes before receiving their maximum dosage.

From the welding point of view what would appear to be required are automatic cutting or welding heads which could be quickly placed in position and which would carry out the operation whilst the worker retired to a safe distance. The type of equipment which might conceivably be used for this kind of work is shown in figure 5, which shows an automatic argon-arc pipe welder for doing the

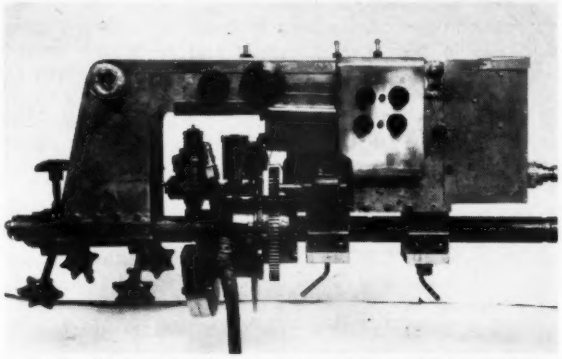


Fig 5 Automatic argon-arc pipe welder could be used in radioactive conditions. It can be quickly placed in position and is operated from a safe distance

rooted run in stainless steel pipe work. Once this is clamped on to the tube the operator can retire, press a button, and the torch will rotate round the tube, completing the weld. A development of this enables filler wire to be used and for the weld to be completed.

Welding unusual materials in quantity

The welding of special materials such as niobium, zirconium, beryllium etc has been covered elsewhere in this issue and the only point to make here is that these may have to be welded in very large assemblies and the question of obtaining the correct protective atmosphere may be difficult when the components concerned are too large to be contained in a vacuum chamber.

An example of this kind of problem would be in the case of a sodium-cooled graphite-moderated reactor where the graphite would have to be protected from the sodium by some material with an acceptably low capture cross-section. This could well be Zircaloy, and this would have to be used either as tubes through the channel or as cans round the graphite. In either case large assemblies are involved.

An interesting example of this kind of fabrication has been carried out in America, where the core for the homogeneous aqueous reactor consists of a 32 in. diameter sphere in Zircaloy $\frac{5}{16}$ in. thick, and this was welded by the use of specially developed trailing gas shields.

Acknowledgment
The writer wishes to thank Sir Leonard Owen, Managing Director, and Dr H. Kronberger, Director of Research & Development, of the Industrial Group for permission to publish this article.

Manufacture of pressure vessels

H. HARRIS, PhD, BSc, DIC, ARCS

Babcock & Wilcox Ltd

FOR SOME THIRTY YEARS the power, chemical and oil industries have used pressure vessels fabricated by welding to what is normally referred to as a Class I standard. During this time developments and experience in welding have been responsible for quite a revolution in the application of pressure vessels so that today vessels 6 in. in thickness in high strength steels and of a size limited mainly by transportation facilities are not infrequently to be seen under construction in the major fabricating shops of this country. Why then is such an interest being displayed in the vessels being constructed and being designed for housing the reactors of the nuclear power stations of the world ?

The answer would seem to be in two directions. In the first place the present reactor vessels for the gas cooled power units are too large for shop manufacture so that their construction involves considerable site fabrication and erection. Secondly it is a matter of surprise to many who have spent the best part of a lifetime in pressure

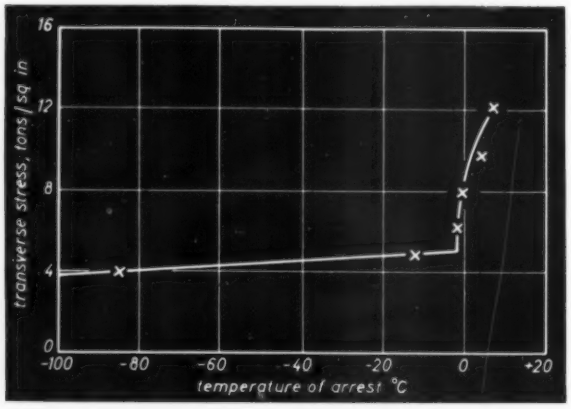


Fig 1 The transition temperature of steel can best be measured by the Robertson test

vessel manufacture to find that factors that have become commonplace within the industry are not always understood in general engineering circles.

One great simplification will be made in this article by limiting it to vessels made of mild steel and to the standard of quality already referred to as Class I. It will therefore be appropriate to consider the service experience of such vessels over the years for which they have been used. It has to be realized that many of the modern and important developments in the power, chemical and oil industries have only been made possible by the use of welding and this in turn was only possible to contemplate because of the unrivalled excellence of previous service experience. Because of the vast number of vessels constructed it has obviously become impossible to make a categorical statement of complete freedom from failure of the welds in Class I pressure vessels, but to many in the industry news of a main weld failure would be very surprising information.

It would therefore be appropriate to consider that once a reactor pressure vessel has been built and accepted as complying with existing Class I specification requirements that the service performance is assured. There is only one new factor for which previous service experience cannot be relied upon in nuclear power production, namely the damage to the steel by irradiation.

Avoiding brittle fracture

The other hazard is that which concerns the manufacturer. It is primarily his responsibility to produce the vessel to the required standard largely under site conditions. Here the principal difficulty would be to minimize the possibility of brittle fracture. In saying this, of course, it will be agreed that one is discounting the purely engineering problems that must inevitably be met in such constructions. Accuracy of dimension and delivery on time are factors easy to enumerate and easy to dismiss by those who do not have to bear any responsibilities, and if those matters which have a profound influence on such aspects are not discussed here, it must not be assumed that they are to be so lightly treated in actual practice.

Brittle fracture deserves some elaboration and it is first of all necessary to define what dangerous situation is implied. The fracturing of steel in such a manner that its quality of ductile behaviour is not clearly apparent is not necessarily a matter for alarm. To those accustomed to dealing with steel in heavy sections this would appear to be the normal mode of failure. However, the rapid rupturing of the steel at low levels of applied static stress would be serious—under these conditions the steel would exhibit little ductility and the occurrence would not be restricted to thick sections of material. It is this behaviour that resulted in serious failures in welded ships and was consequently the reason for the extensive and prolonged investigations into the phenomenon generally known as brittle fracture. It would be inappropriate here to discuss brittle fracture in any detailed sense and an attempt will therefore be made to restrict discussion to relevant features.

As far as modern research goes it would appear that for brittle failure, in the sense defined above, to occur in a welded structure, three factors have to be present.

1. the material has to be at a temperature below its ' transition temperature.'

2. the weld must contain a defect from which the fracture can be initiated.

3. residual welding stresses must be present.

It is part of the specification for Class I welded pressure vessels that after all welding they shall be subjected to stress-relieving treatment. Consequently it is not surprising to learn in view of the third requirement enumerated above that, as far as the writer is aware, there is no authenticated example of a Class I vessel having failed in a brittle manner in service at low applied static stresses. In order to make doubly sure, if such a premise can be accepted, the second requirement listed is almost impossible in a Class I vessel which, during construction, has to be subjected to quite rigid non-destructive examination.

But it will be appreciated that both these two factors can be present at some stage during manufacture of a pressure vessel and at this stage not very much can be done about them. Certainly the residual stresses will be present and defects of a greater or less magnitude can be expected before the vessel is non-destructively examined. The constructor therefore has to determine what steps can be taken to minimize the possibility of brittle fracture during construction by considering what can be done about the first requirement.

In the construction of a large reactor vessel of the type now under consideration—say a sphere 65 ft diameter and 3 in. wall thickness—the welded seams will be tested non-destructively as the work is proceeding and consequently the applied stresses due to the deadweights involved will not usually be great in a seam which has not yet been examined. This in itself is some safeguard against failure but of more importance is the selection and treatment of the steel employed.

Measuring transition temperature

Reference has been made to the transition temperature of a steel. There is no precise meaning to this term. What is intended is the temperature range at which there is a change in the mode of failure of a notched steel, the change being from ductile to brittle. The lack of precision derives from the fact that different forms of test give different temperature ranges, in fact with a given form of test the same steel has a transition temperature range which varies with the dimensions of the specimens. It is however well recognized that this situation exists but it is not so well recognized that the data from any single type of test cannot be interpreted with any great precision in industrial practice.

The usual laboratory method of assessing the transition temperature is by the Charpy V-notch impact test and there is no quarrel with this test provided that the data is interpreted somewhat as a qualitative rather than a strictly quantitative guide to the energy-temperature relationship of the fracture initiation. Of much more use to the engineer is the Robertson test. In this a specimen is subjected to a uniform applied stress and also to a temperature gradient. At the cold end is a sharp defect—a saw cut—and a crack is initiated from this defect by means of a blow. The crack propagates under these conditions and the temperature at the point where the failure changes from brittle to ductile is known as the crack arrest temperature. From a series of such tests carried out over a range of applied stresses, Robertson arrives at a curve similar to that of fig 1. It will be seen from this curve that there is a temperature at which the stress required to propagate a brittle fracture increases rapidly. This is a transition temperature for the steel investigated.

Of even more direct importance to the welding industry is the work of the British Welding Research Association on the fracture of welded plates. In these tests a longitudinal butt weld in a 3 ft wide plate assembly contains an artificial defect produced by a saw cut in the plate edge preparation of the weld before the weld is made. The plate zone containing the defect is maintained at a pre-selected temperature and a tensile stress applied to the plate assembly in the direction of the longitudinal weld. The stress at which failure takes place and the character and length of the crack are then recorded.

Plotting the stress for failure against the temperature,

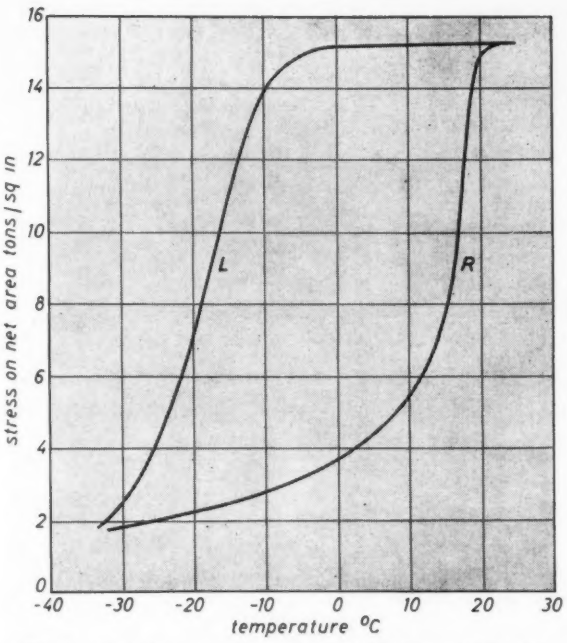


Fig 2 In tests on fracture of welded plates, stress for failure is plotted against temperature and a transition behaviour found. Curve R is from plates welded with a rutile electrode; for L, low hydrogen electrodes were used

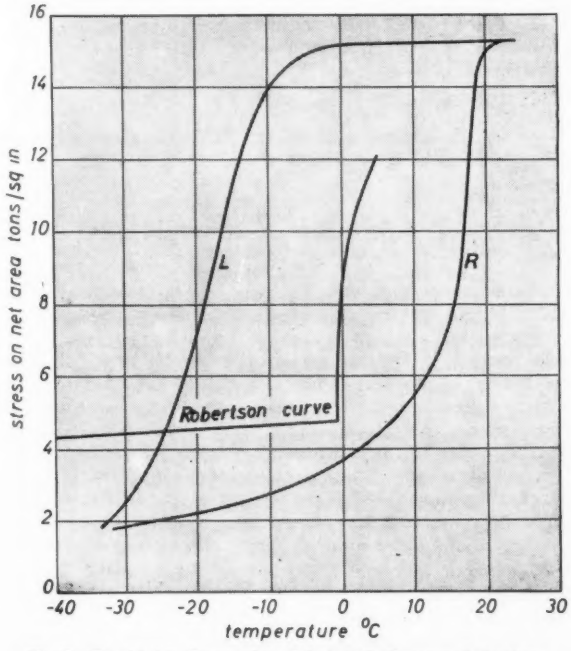


Fig 3 Combining figures 1 and 2, brittle fracture behaviour of a particular steel can be predicted

again a transition behaviour is found (fig 2). In both the curves shown here it is seen that, for the steel examined, at a sufficiently low temperature it is only necessary to have stresses of a very low magnitude for failure to occur. Of great practical importance however is the difference

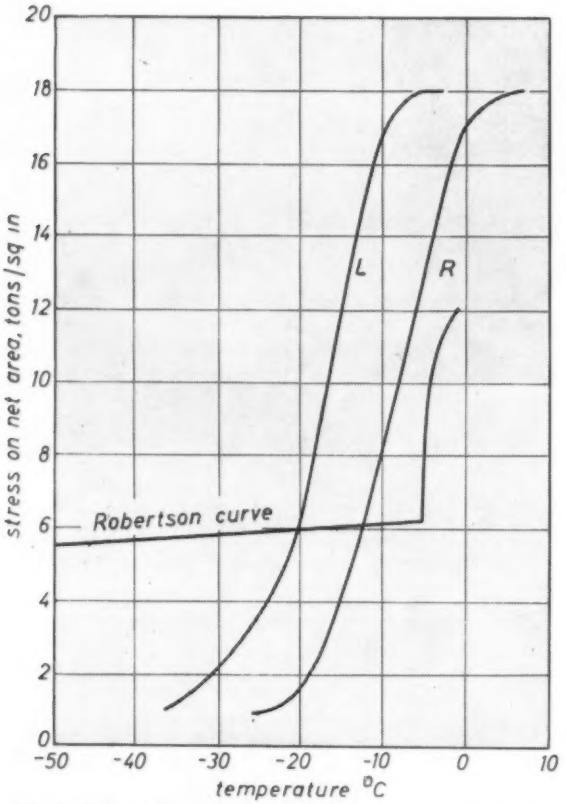


Fig 4 With a more notch-ductile steel than that of fig 2, curves R and L are shifted to lower temperatures and the gap between them reduced

between the two curves. That marked R is from a series of test plates welded with a rutile electrode whilst the other designated L is with plates welded using low hydrogen electrodes. The marked superiority of the low hydrogen electrode is obvious. This is certainly not due to any marked improvement in the notched impact value of the weld metal, and thus a widely held view that the notched impact value of the weld metal is all-important has to be revised drastically. Three explanations seem possible: one is that the weld metal from the low hydrogen electrode is free from micro-fissures and thus in some way renders initiation of failure more difficult; the second is that the much higher hydrogen content in the weld metal from the rutile electrode diffuses into the parent metal surrounding the artificial defect, thereby increasing the transition temperature in this locality; thirdly the weld metals, in the presence of the saw cut, may exhibit greater or less proneness to crack on a macroscale. But whatever the explanation may be, the facts are there. As a result of this type of experience, it is anticipated that a revision of some practices favouring rutile electrodes because of their greater ease of manipulation for positional welding will be observed in reactor vessels being currently erected.

If figures 1 and 2 are combined as in figure 3, we are able to predict the brittle fracture behaviour for the particular steel used with an artificially-produced defect and how it is influenced by the type of electrode. Conditions covered by the zones to the right and below the Robertson curve will mean that any crack that may be produced will not propagate indefinitely, whereas curves R and L indicate under what stress and temperature conditions a crack will be initiated.

So far we have been concerned with reporting the behaviour found with one particular type of steel. When however a more notch-ductile type of steel is available, it is found that the same pattern of behaviour persists but that the two curves R and L are shifted to lower temperatures, and further that the gap between them is decreased (fig 4). This type of data is obviously of considerable help in deciding the materials that are to be used; but one factor is still missing.

It has already been indicated that the thickness of the steel has an important bearing on the ductile-brittle fracture characteristics but little systematic work has been available to elucidate in any detail the pertinent factors. It is therefore not surprising that the BWRA are now actively engaged in extending their work on the brittle fracture of 1 inch plate to material 3 inches in thickness. Until this data is available it would perhaps be futile to theorize in too great a detail.

Irradiation damage

Brief reference has been made earlier to the irradiation damage that steels might undergo as the result of neutron bombardment. This is a subject about which data is still scarce. The major effect of irradiation is in the change that takes place in the transition temperature. It is displaced to higher temperature levels and the extent of the change is quite understandingly dependent on the time and intensity of the neutron flux and also on the temperature. The damage would appear to be greatest when the temperature of the steel is in the range 100-200°C and at temperatures in excess of 350°C it might well be that the effects are only slight. But the major factor that still eludes the designer of reactor vessels is accurate data on the actual flux intensity and on the radiation spectrum. It is therefore extremely difficult to forecast both the extent of the possible damage and also the effect that the anticipated change in the transition temperature would have on the service performance of the reactor steel. At our present stage of knowledge it is of course hoped that the effects of radiation on the anticipated life of the reactor will not be sufficiently pronounced as to give cause for any anxiety.

It will be seen from this rapid sketch that care has to be exercised in the choice of the type of mild steel for a reactor vessel. The choice would appear to have been narrowed down to two general types. Both types specify maximum carbon contents at a sufficiently low carbon level to promote easy weldability. One type will be grain-controlled by a large aluminium addition, the effects of which are to produce steel with a low transition temperature but with laminar planes of weakness. The other type is a silicon-killed steel with which pressure vessel manufacturers have extensive experience both in fabrication and in service and the soundness of which is not affected by aluminium additions. It has a somewhat higher transition temperature—as determined by conventional tests—than the former steel, but it is uncertain whether the more pertinent and informative tests of the BWRA programme will justify the confidence that some authorities are prone to place in the Charpy V-notch tests.

Having selected the steel it is of course important that the fabrication should not adversely affect the potential qualities of the steel by malpractices during production. For such reasons, the plates will have to be processed under controlled temperature conditions and all site welding should be carried out with an adequate pre-heat and inter-pass temperature.

Manufacture of heat exchangers

P. K. RICHARDS, BSc(Eng), AMIMechE

John Thompson Water Tube Boilers Ltd

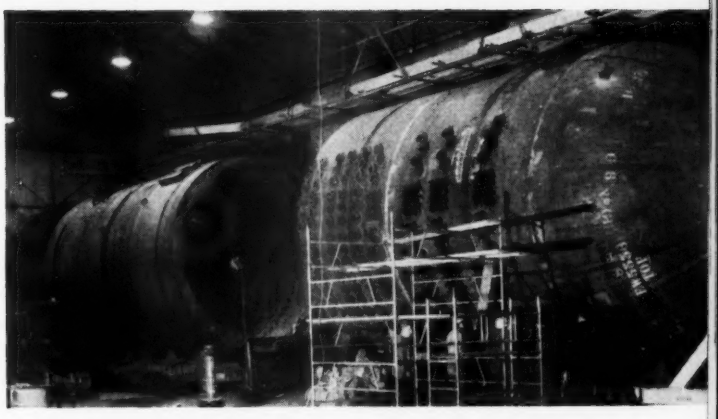


Fig 1 Nearing completion in the site assembly shop is this heat exchanger shell for Berkeley. Method of fabrication in rings of $1\frac{1}{8}$ in. mild steel can be clearly seen

THE SIZE OF the heat exchanger shells for nuclear power stations at present being constructed is intermediate between that requiring complete site fabrication, as in the case of reactor vessels, and that sufficiently small to be manufactured complete in the works and transported without difficulty as in the case of boiler steam drums. Where the site and the manufacturer's works are placed relatively near to the sea, it is possible for the shells to be works fabricated and then floated to site. But the more general case is the one where the shells are part fabricated at the works and finally assembled at site.

In future power stations, gas pressures and temperatures will be higher, outputs will be greater, and consequently

Fig 2 Stress relieving of circumferential seams is one of the greatest problems. Here induction heating coils are being applied to the outside of the shell

the heat exchanger shells are likely to be thicker and of greater diameter. These vessels now become more like the cylindrical reactor vessels with their corresponding problems and difficulties, and relatively little works prefabrication is possible. The balance of the work, particularly on the site, thus swings in the opposite direction, and the heat exchanger shells now present the greatest organizational problems instead of the reactor vessels. Further, the total time required for construction of such a station depends on the time required to complete the heat exchangers. A typical shell is shown in figure 1 nearing completion in the site assembly shop.

The heat exchanger shells for Berkeley are fabricated in rings of convenient length in mild steel plate, $1\frac{1}{8}$ in. thick, cold rolled. Plate edges are examined by ultrasonic methods prior to welding, and also a very searching investigation is made in areas where holes are cut for the various connexions. After rolling, the holes in the plate are cut and the weld preparations shaped.

Welding the main seams

The plates forming the shell are left over-size and not finally cut until welding of connexions has taken place. This allows the butting edges of the main weld seams to be prepared truly without being affected by weld shrinkage. It was feared that excessive distortion might take place because of the amount of welding around the closely spaced thermal sleeves. In practice this has not been found to be such a problem as suitable jigging reduces distortion to negligible amounts.

The longitudinal seams between the two half rings are now completed by the *Unionmelt* process, ground, and X-rayed. Strangely enough, these relatively simple seams have been a greater problem, because although distortions in themselves were not excessive, they could be sufficient to prevent a proper lining-up on site with adjacent rings. The rings have a large diameter to thickness ratio, and are rather flexible and very careful welding control was necessary.

After the final cleaning up operation, the sleeves are inserted and held in position by jigs. The purpose of these sleeves is to lead the boiler tubes out of the pressure shell either in groups or as individual tubes as most convenient to the arrangement. Incidentally, thermal sleeves are used to allow a certain amount of flexibility and to prevent excessive stresses being thrown on the pressure vessel shell, because of the difference in temperature of the tubes and the main shell.

Root welds are back chipped and crack detected before subsequent welding. Completion of welding is then carried out from alternate sides to control distortion. Welds are finally crack detected and the shell section goes forward

for stress relief. The edges of the rings which will make up the circumferential welds at site are finally trimmed at this stage.

Dome ends are made in petals, cold pressed, flame cut and welded on a jig. One of the problems which have had to be overcome is the difficulty of welding the large reinforcing ring at the main gas inlet and outlet openings without distorting the shape of the hemispherical end. The ring has to compensate for the large diameter openings necessary for the gas inlet and outlet.

Site assembly and circumferential welding presents no particular technical problems, although there are some practical snags in handling and rotating vessels of such a large diameter. The greatest problem that has been met has been stress relieving the circumferential seams. It is relatively easy to bring the temperature in the immediate vicinity of the weld up to suitable stress relieving figures, but it is very difficult to maintain a reasonable temperature gradient either side of the seam. It is further complicated by the effect of the large number of thermal sleeves occurring fairly near to the weld, tending to cause a lower temperature in the area where the greatest amount of metal occurs. It will be appreciated that no object is served by reducing the locked-up stresses in the weld to a satisfactory level whilst replacing these by stresses in other areas of the shell at unacceptable levels.

It can readily be proved that stresses set up while raising the temperature of the shell which do not cause yielding in that area disappear on cooling down. However, those

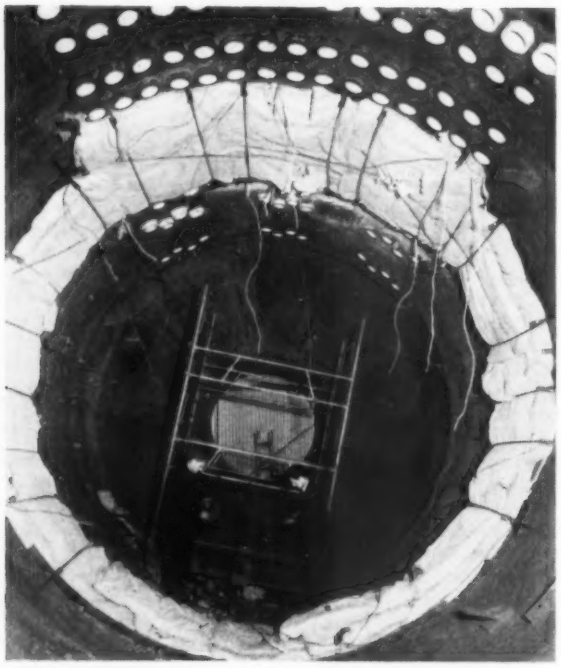


Fig 3 During stress relieving, the seams have to be insulated internally to maintain the required temperature gradient and distribution

that do cause yield, which can occur quite readily at temperatures of the order of 600°C-650°C, leave similar stresses of the opposite sign frozen in the vessel when it cools down. Figure 2 shows the induction heating coils being applied to a seam and figure 3 shows the insulation necessary internally to maintain a reasonable temperature gradient and distribution around the circumference of the shell. In addition to this, it has been found necessary to use supplementary heat in particular areas where it is found in practice that the required temperatures are not obtained. The pattern of heating can only be found by experience and varies with each different arrangement of branches and thermal sleeves.

Finally the shells are pressure and leak tested and then transported to their site adjacent to the reactor vessel

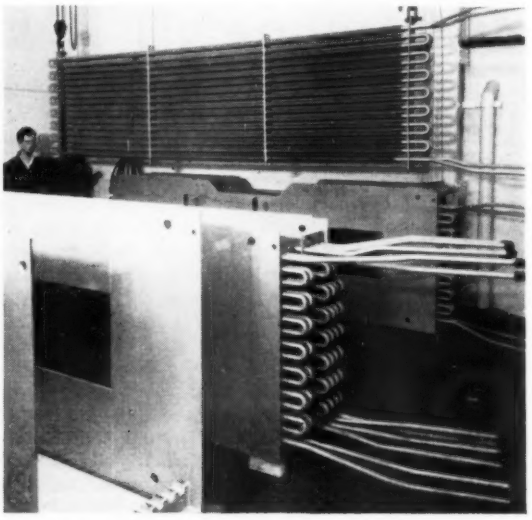


Fig 4 After shot blasting and cleaning, finished nests of fin tube elements are packed into containers in this air-conditioned section of John Thompson's works

and lifted into position. At this stage, the vessels are approximately 18 ft by 80 ft and weigh 150 tons.

The fin tube elements which go to make up the boiler heating surface have also to be fabricated under strict conditions of control and inspection. These may either be fabricated in small units and cleaned at site to the required standard, or cleaned at the works and fabricated into convenient nests. The later process shows definite advantages in erection time, but it does mean that special arrangements must be made for packing and transporting to site. The finned tubes are flash welded at the works onto formed return bends. The usual hydraulic testing is applied and in addition a vacuum test, using the pulsating principle to reduce the time of testing to a minimum.

Mounting on site

After fabrication tube nests are shot blasted and very strictly cleaned. Figure 4 shows the air conditioned and controlled section of the shop where these finished nests are packed into containers to obtain the last degree of cleanliness. The nests themselves are enclosed in a polythene bag, containing silica-gel as a desiccator.

At site, the nests are raised up to the clean conditions house, mounted at the top of the heat exchanger vessel where they are removed under clean conditions and, after passing through an air lock, lowered into the shell. Final site welding consists of a cap which makes the joint between the tubes and the thermal sleeves.

In conclusion, no very great technical problems present themselves in heat exchanger manufacture and erection for the present series of nuclear stations, but future designs will require all the skill and ingenuity available in design, in techniques and organization that have at present been concentrated on the reactor vessels. The development of high speed automatic welding processes may well be an essential requirement to meet construction programmes.

Welding Symposium **4**

Welding aluminium and its alloys to nuclear standards

N. T. BURGESS, AIM, AMInstW

Aluminium Development Association

(Courtesy of APV Co Ltd, AEI-John Thompson Ltd and UKAEA)

The MERLIN reactor core tank, fabricated in aluminium is here being welded by the inert gas, metal-arc technique

AT PRESENT there are few specifications relating to the welding of aluminium, but recommended practices are fully detailed in various publications (*1*). This situation is shortly to be rectified and a British Standard will soon be issued covering recommended practices for argon-arc welding. Another BS is in preparation covering recommended methods of testing aluminium welds. In the meantime, authoritative information on welding and inspection is readily given by research and development associations and leading companies in this field. This brief article covers the most important points in aluminium welding technology, highlighting those aspects which are of particular value for highest quality welding, into which category much of the atomic energy work must fall.

Aluminium of 99·5 pct purity has been widely used in experimental reactor tanks, the construction of which has been fully described by Lancaster (*2*). Ancillary equipment, tanks and vessels are also frequently made from pure aluminium. Piping is of pure aluminium where corrosion resistance is important or alternatively of heat treatable alloy H9 or aluminium-magnesium alloy N5. Structural parts, servicing platforms, etc, are made from alloy NP5/6 or the medium-strength, heat-treated alloy H30-WP. Aluminium of 99 pct purity was used for the 3 ft diameter torus of ZETA.

The composition, properties and weld values of a selection of materials used in atomic energy are given below:

BS 1470-1477	composition (pct) Mg	Si	Mn	property range ·1 pct PS	UTS	typical weld efficiency (pct)
1B—0	—	99·5 aluminium		—	6·0	up to 100
1C—½H	—	99·0 aluminium		—	7·8·5	up to 100
NP5/6	3·5-5·5	·6 max	1·0 max	8·0	17·0	90-100
H9 WP	·4-·9	·3-·7	·5 max	10·0	12·0	60 as welded 90 re-heat treated
H30-WP	·4-1·5	·6-1·3	·4-1·0	16·0	19·0	60 as welded 90 re-heat treated

Although the oxyacetylene process is still quite widely used, the inert gas processes, because of their speed, flexibility over a range of unlimited thicknesses, ease of application, economy and efficiency, are invariably used for the welding of atomic energy equipment. The argon-arc process, using a tungsten electrode is most adaptable, being used over a range of thicknesses, chiefly 14 swg to $\frac{1}{4}$ in. automatically or manually, with or without filler rod. It is particularly suited to short runs, tack welds, etc, which may be unsuitable for the inert-gas metal-arc or consumable electrode process, developed from the earlier process. The high speed of operation and ability to weld satisfactorily in all positions also make the latter process a desirable tool, particularly where the plate is being welded. It is the process most suited to fillet welding where good penetration can be readily obtained. Both techniques are applicable to all the alloys welded, and the efficiency of welds made with either process is high, despite an inherent tendency for some dispersed porosity with consumable electrodes. This is considered to be due to several factors including introduction of moisture down the contact tube, a high cooling rate, weld pool turbulence and the introduction into the weld of cold wire which may bear hydrated aluminium oxide and a thin layer of worked-in dross and lubricant.

Importance of cleaning

The essence of the satisfactory welding of aluminium is cleanliness; for high quality welding the recommended procedures must be rigidly applied. Fusion faces must be free from grease, dirt, moisture and excessive oxide film as these increase the risk of porosity and oxide film entrapment. Applied finishes such as protective lacquers must also be removed prior to welding. Sheared and sawn edges should be smoothed by filing or milling and finally degreased with carbon tetrachloride, acetone, or trichlorethylene. In special cases, or where the plate has a heavy oxide film, pickling in caustic soda may be necessary. Immediately prior to welding, the fusion faces should be scratch-brushed with hand or rotary brushes, care being taken so that bristles or wires remain near the joint.

For thick plate welding, such as is involved in the construction of reactor tanks, preheating may be necessary to ensure initial or interim fusion, and oxypropane or oxybutane torches are used for this purpose. Although temperatures up to 300°C may be required in some circumstances, slight preheating to temperatures of the order of 100°C is often all that is required to obtain satisfactory fusion. Care should be exercised throughout, however, due to the risk of distortion. The size and location of residual

porosity can also be affected by the extent of preheating. When welding thick plate, a tendency for hot cracks associated with larger grain size in the solidifying weld can be partly countered by cooling between successive passes.

Suitable edge preparations are suggested in various documents. For butt welds in plates thicker than $\frac{1}{4}$ in. it is good practice to use more than one pass, to chip back to sound metal on the reverse side, and to add a sealing run. Where access to the underside of the joint is restricted, single V or U preparations can be used, the root pass being made by manual argon-arc to obtain sound penetration, the joint being completed with the inert-gas, metal-arc process. Stainless or mild steel backing bars, used in conjunction with a suitable current, are to be recommended as an insurance against lack of penetration. For welds in

(Courtesy of Northern Aluminium Co Ltd and Fairey Aviation Co Ltd)

Welding in progress on the large mushroom cover to diffusion equipment in NP5/6 alloy

most thicknesses a root gap is not considered necessary. Wherever possible rollers, manipulators and jigs should be used so that welding can be carried out in the most convenient position to achieve sound welds. Horizontal-vertical butt joints should be avoided. Tack welds should be spaced at regular intervals along the joint (about 3 in. apart) and for materials up to $\frac{1}{8}$ in. should fully fuse the metal. Above this, tacks should penetrate about $\frac{2}{3}$ of the thickness and should be chipped out before the final weld is made. At all times extreme care must be taken to remove deposits and dirt before adding the first or subsequent passes, and scratch brushing between passes is required.

Extreme care should be used in the selection of filler rods as incorrect combinations of parent filler metal can lead to cracking troubles and differential behaviour under corrosive media. Filler rods should be specified and used in accordance with BS 2901 ; 1957 *Filler rods for inert gas arc welding—Part 1. Tungsten arc welding: Section G. Aluminium and aluminium alloy rods*. In general, pure aluminium should be welded with rods of parent metal composition or slightly purer. Aluminium-magnesium alloys should be welded with NG6 (5 pct magnesium). Heat treatable alloys of the aluminium-magnesium-silicon type may be welded with either NG21 (5 pct silicon) NG6 (5 pct magnesium) or NG2 (10 pct silicon). For high quality work, rods and wires should be bonded in store and only issued for the particular work in hand.

Inspection and testing

The standards of inspection will vary according to requirements. Reactor tanks and vessels are of such importance from the leakage point of view that they are invariably subject to 100 pct radiographic inspection, whereas ancillary piping, such as for effluents, will not normally be radiographed at all. Mechanical tests will often supplement this examination, the most common being a tensile test to indicate weld strength and the presence and size of any imperfections, and a bend test. Although tranverse tensile tests generally provide all the information necessary on butt welds, bend tests may be substituted where these facilities do not exist, to provide comparative values of weld efficiency. Aluminium welds are, however, liable to bend in a non-uniform manner—'peaking'—and only a guided bend test should be used. In this test a specimen is bent round a suitably sized mandrel by a roller which closely follows the contour of the weld to yield a uniform radius to the bend.

Nicked break tests, and macro-examination of the weld are further tests that provide useful information about the condition of the aluminium weld. Fluorescent penetrants are frequently used for crack detection.

Test pieces must always simulate the actual work in hand and for seam welds coupons should be attached to the longitudinal seams. Fillet welds can be broken by knocking over in the vice, and this will generally indicate the extent and effect of any weld imperfections.

In the atomic energy field there is an increased tendency for radiography to become the main method of weld inspection. Such examination must show freedom from oxide film, good fusion and absence of cracks. Porosity associated with restart positions, and dispersed porosity up to $\frac{1}{16}$ in. is generally accepted. The effect of such porosity on static weld properties has been found to be negligible, and quite large pores do not appear to reduce the efficiency of the weld. Nevertheless, rectification is sometimes required, in which case special care should be taken because pores can increase in size and extent as a result of this operation.

Other defects may prove more troublesome and these may include oxide film entrapment, arising as a result of temporary argon turbulence or indifferent cleaning. Lack of fusion between passes is invariably due to poor cleaning, chilling or incorrect techniques. For full weld strength and perfect leak tightness these defects must be avoided.

Joint efficiency

Welds in the various grades of pure aluminium yield up to 100 pct of the annealed parent metal strength and where the parent metal is in a work hardened condition, the weld itself can be worked to improve slightly its overall strength and hardness. Working in this manner, by hammering, peening or wheeling, breaks up the cast structure of the weld to yield a sounder structure which also shows improved corrosion resistance over unworked welds. Welds in the aluminium-magnesium alloys are not so easily worked in this way, but as-welded strengths readily approach 100 pct of the annealed parent metal. Welds in heat-treated alloys will generally fail in the heat affected zone adjacent to the weld to give an efficiency of about 60 pct. Where reheat treatment is possible, weld efficiencies up to 90 pct are common.

Aluminium, with low neutron absorption characteristics and good corrosion resistance, has shown itself to be a most satisfactory material for certain types of water-moderated nuclear reactors. The alloys of aluminium, with greater strength and similar inherent physical properties, have been widely applied for items of diffusion plant, heat exchangers and other equipment pertaining to nuclear engineering. In fabricating these components, specially developed techniques and attention to welding metallurgy have paid dividends in attaining a very high standard of weld quality and efficiency.

References

1. *The arc welding of aluminium*, ADA Information Bulletin No 19; *Argon arc welding aluminium*, Booklets published by BWRA
2. 'The welding of aluminium tanks for experimental reactors,' *Brit Welding Journal*, 1957, *4* (Aug) p 354-60

Welding magnesium alloys

I. H. MORRISON, MA(Cantab), ARIC, AInstM & A. F. TAYLOR, BSc, IAM

UKAEA Industrial Group, Springfields

THE FUEL ELEMENTS used in the Calder Hall reactors are canned in a magnesium alloy and a similar material is being considered for use in some of the industrial reactors. The development work described here is an outline of the steps followed in connexion with the Calder Hall cartridge and serves to indicate the main points associated with producing a satisfactory seal in this material by welding.

When magnesium alloys were first contemplated it was anticipated that corrosion resistance under working conditions would be the most difficult requirement to meet, and a series of suitable alloys was therefore developed. The first alloy chosen contained aluminium, calcium and beryllium in addition to the magnesium and gave rise to cracking when welding. It was known that the presence of calcium in excess of 0·4 pct could cause this phenomenon when making a restrained weld so several different designs of joint were considered which would reduce the degree of restraint. However, the cracking could not be eliminated entirely so calcium was excluded from the alloy without any significant loss of corrosion resistance in carbon dioxide.

Seal by single argon-arc weld

The earlier designs of fuel elements for the Windscale piles had made use of aluminium as the canning material and it was possible to make a double seal by both welding and brazing. With magnesium however no reliable brazing technique was known and it was decided that the seal would have to consist of one weld only. This meant that the single weld must be consistently reliable and great care must be taken to ensure this. A good deal of experience had been obtained on sealing tubes by making an edge weld on a simple dished end cap placed in the tube. This type of weld is comparatively easy to make and is less prone to cracking than other joint designs since it offers less restraint. In view of the somewhat low ductility of magnesium, we chose to develop a method of sealing this type of joint by argon-arc welding with a non-consumable tungsten electrode. Keeping the ultimate production requirements in mind, it was decided that it would be preferable to keep the can vertical and stationary and allow the torch to revolve round the top edge.

Having demonstrated that the proposed technique was feasible, the investigations were concentrated on producing the best design of weld joint and determining the effect of the welding variables. The method of assessment established initially was to section the weld and measure the quality by the depth of penetration achieved. In order to fix the weld joint design, the variables considered were the height of the end cap wall, the wall thickness of cap and can, and a comparison between square joints and vee joints. Having determined a suitable design of joint, the main welding variables were considered, these being the method of cleaning the joint, current, welding speed, argon flow, electrode material and size, and arc gap. A series of experiments was planned to investigate the effect of one variable at a time and a sufficient number of welds was made for each given set of conditions for a statistical analysis of the results. Each weld was examined externally for cracks and then cut into twenty-four sections and the minimum penetration at each section was measured. Fig 1 shows a typical section and it can be seen that the depth

Fig 1 In investigations to produce the best joint for the Calder cans, each weld was cut into 24 sections like this and the minimum penetration measured

of the molten zone is greater than the thickness of each member of the joint, but the effective penetration is reduced by the persistence of an oxide film at the interface. The penetration measured was the minimum distance between the tip of the oxide film and the surface of the weld. Statistical methods were used to determine the significance of the results in a series and also the confidence with which the results from twenty-four sections might be felt to represent the whole.

It was found that in order to obtain the maximum penetration, the joint should have a vee preparation about

0·050 in. deep and 45 deg included angle and should be cleaned with a fine wire brush immediately prior to welding. Also the fit of the end cap in the can could introduce variations in the results and in general a tight fit minimizes any reluctance of the two members of the joint to flow together during welding. It must be pointed out that the seal is produced by fusing the joint and no filler wire is added.

Optimum welding conditions

As a result of the investigations, the optimum welding conditions were established as follows. Welding power was obtained from an a.c. set of 110 open circuit volts with a condenser bank in circuit for d.c. suppression. A thoriated tungsten electrode of $\frac{3}{32}$ in. dia and an argon flow rate of 6 litre/min were used. At a current of 48 amp and a cold arc gap of 0·004 in. the arc is initiated by a superimposed high frequency current and the torch held stationary for about four seconds to allow the weld pool to form. Welding then commences at a speed of 18 in. per minute and on completion of the first revolution the torch is raised 0·045 in. for a second run. On completion of the second revolution plus an overlap, crater formation is avoided by a gradual reduction of the welding current by means of a variable resistance until the arc is extinguished. Using these conditions, an average penetration of not less than 0·040 in. could be obtained and statistical analysis showed that it was unlikely that the penetration would fall below 0·030 in. at any point in the weld.

In order to minimize variations due to human error it was necessary to make the welding automatic, and the machine developed for this purpose is illustrated in fig 2.

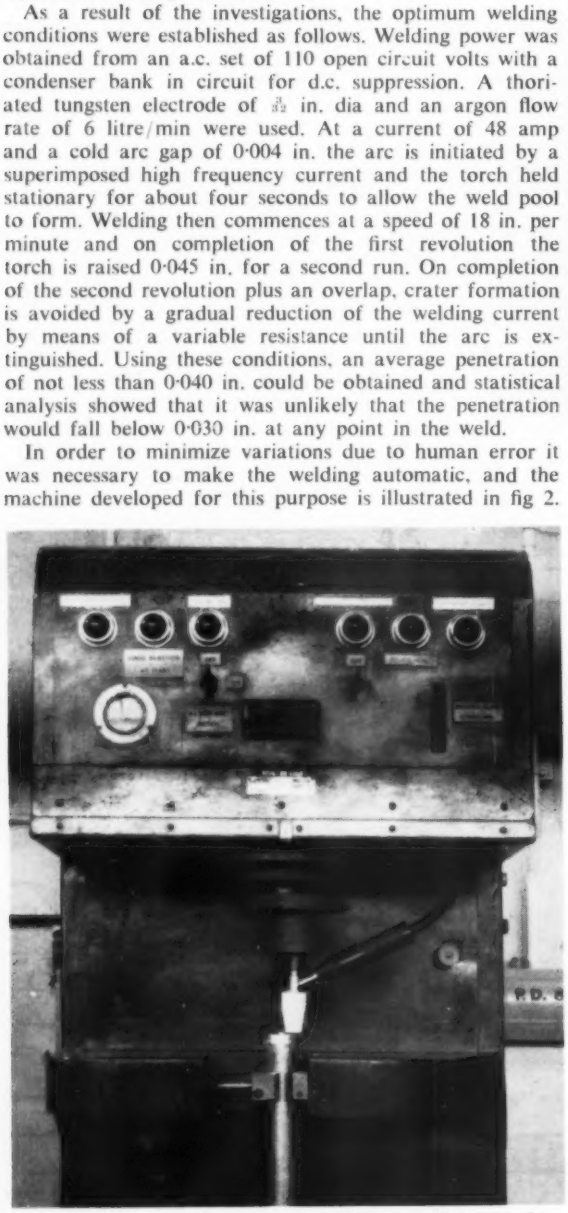


Fig 2 This automatic argon-arc welding machine was developed by the AEA to minimize human error. Fuel element at foot of picture is held by a pneumatic clamp, released at the end of the welding sequence

It consists essentially of a motor driven vertical shaft which drives the torch on a circular orbit above the weld joint. In addition, the motor drives a camshaft which controls the welding sequence of arc initiation, time delay, alteration of arc gap, switch off and release of the pneumatic clamp holding the fuel element. This final action stops the machine and it is ready for the next cycle. The quality of welds produced by this means is shown in fig 3 where it can be seen that the weld bead is perfectly even and smooth. Apart from visual inspection, the quality of the weld is checked by radiography and quality control is maintained by sectioning a percentage of all welds. Also leak tightness is checked by a mass spectrometer.

Development work has continued throughout the manufacturing period and as a result of the experience gained in both fields a new automatic argon-arc welding machine has been produced. Greater control of all the welding variables has been achieved and several new features have been introduced. For example the welding current is maintained constant regardless of variations in the mains voltage and better arc stability is obtained by surge injection in place of superimposed H.F.

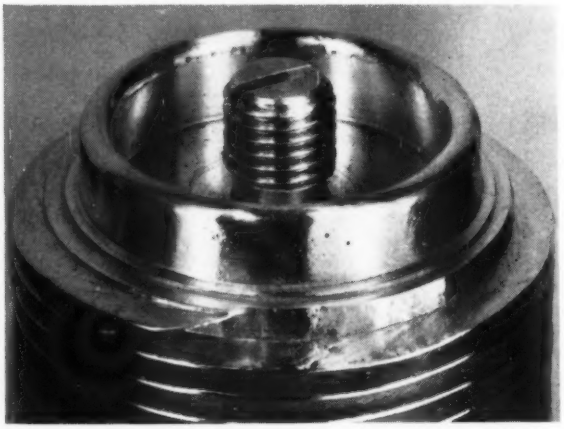


Fig 3 This is the type of weld quality produced by the automatic machine: the weld bead is perfectly even

New developments

A further variant is removed by compensating for input voltage variation and so maintaining the welding current constant. Incidentally the transformer designed for this work is smaller and more suited to the current requirements than was the equipment originally used, which was working at the bottom of its range. The original tail-off as mentioned above was accomplished with a sliding resistance but this had a rather high maintenance requirement and was subject to some uncertainties of operation. This is being replaced by a saturable core reactor which allows current alteration without requiring moving parts. A new manufacturing assembly line has been associated with some geometrical changes and the operation is now being done horizontally with the can rotated relative to the torch.

All the welding referred to above is connected with sealing the uranium bar inside the can. There are other small requirements and new developments are demanding other techniques. Fittings, for example, can be resistance spot-welded in this alloy using a condenser discharge machine provided precautions are taken against copper pick-up from the electrodes by the use of an iron interlayer. Reactor operation demands that copper contamination is completely eliminated. It is not sufficient to rely on cleaning after the operation. It is also likely that the comparatively new argon-arc spot welding technique will have application in modifications now in hand.

Acknowledgments
Thanks are due to the Managing Director of the Industrial Group of the UKAEA for permission to publish this paper and to colleagues at other Authority laborator.es where some aspects of the work were considered.

Welding techniques for the rarer metals

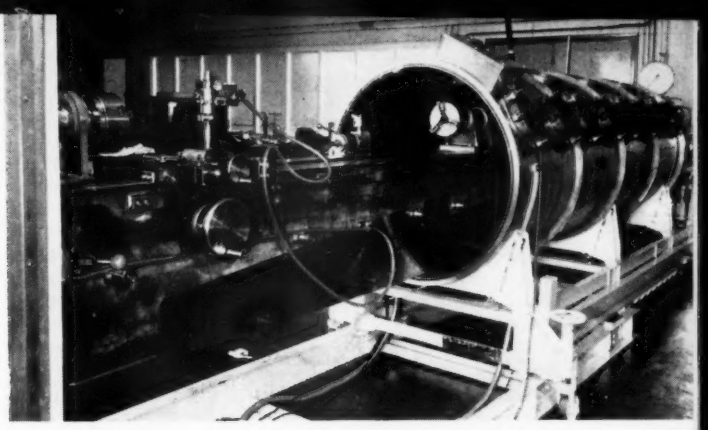


Fig 1 Reactive materials may be inert-arc welded in a controlled atmosphere chamber of this type. Manipulation and manual welding is done through glove ports

D. R. HARRIES, BSc, PhD and J. G. PURCHAS

Metallurgy Division, Harwell

THE ADVENT of nuclear powered reactors has necessitated modification of existing processes or the development of new techniques for welding special materials. Very high standards of welding are required since many components fabricated by welding have to contain, with absolute reliability, materials which are not only very valuable but both toxic and radioactive. This paper describes briefly the welding of some of these less conventional metals.

ZIRCONIUM

The low absorption cross-section of zirconium for thermal neutrons, together with its excellent corrosion resistance and relatively good strength up to moderately high temperatures, have made it a valuable material for use in nuclear reactors. It has been used most extensively in alloys for fuel element cladding in pressurized water reactors and as a diluent for uranium fuel. However, the metal reacts rapidly at elevated temperatures with oxygen and nitrogen and small amounts of these gases increase the hardness and tensile strength and lower the ductility. In addition, nitrogen contamination has a deleterious effect on the corrosion resistance, particularly in high-temperature water.

The argon-arc welding process is an obvious choice for fusion welding such a reactive metal and zirconium possesses a combination of properties which make it amenable to joining by this technique. The liquid metal flows quite readily and it has a high solubility for its own oxide. The metal has a low coefficient of expansion which contributes to low distortion during welding. Both alternating and direct currents have been used, but straight polarity d.c. (electrode negative) is now universally preferred.

The argon flowing from the standard tungsten-arc welding torch does not provide sufficient shielding of the weld areas and a modification of this process for welding reactive metals has been described (*1*). The work is held in a jig having an argon backing groove and this back-up also serves the purpose of a chill and increases the rate of cooling. A trailing shield also carrying argon helps to protect the surface of the metal from oxidation after the main shield has passed, but this is only necessary when welding thick plate which holds the heat for a long time.

Butt welds have been made by this technique in zirconium sheet (0·02 to 0·06 in. thick) with no edge preparation, except careful shearing to produce straight edges, and without filler rod such that the hardness of the welds is not greater than that of the parent sheet (*2*). Zirconium is also amenable to machine welding and the faster welding speeds obtainable are advantageous for minimizing contamination.

Approximate welding conditions are given in Table I.

TABLE I

Argon-arc welding data for zirconium sheet (1) d.c. electrode negative, 99·8 pct pure argon.

sheet thickness (in.)	tungsten electrode dia (in.)	argon shield nozzle dia (in.)	argon flow: torch cu ft/h	argon flow: back-up cu ft/h	welding current (amps)	welding speed in./min	weld
0·020	1/16	3/8	14	5	40	50	machine
0·030	1/16	3/8	14	5	45	—	hand
0·040	3/32	1/2	14	5	60	25	machine
0·050	1/8	1/2	16	5	55	—	hand
0·060	1/8	1/2	16	5	80	25	machine

Welds made using a modified tungsten-arc welding technique, are satisfactory for many applications (*1*) (*2*), but where corrosion resistance is required it is imperative that gas pick-up, particularly nitrogen, be kept to a minimum.

A controlled atmosphere chamber suitable for the inert-arc welding of reactive materials is shown in fig 1. The unit is loaded with specimens, purged by evacuating and then back-filled with inert gas. The equipment is fitted with posting ports through which specimens can be introduced without opening the chamber to air, and glove ports are provided to enable manipulating and manual welding to be done in argon at atmospheric pressure.

Zircaloy-2* butt welds which are corrosion resistant in 325°C water can be made if the specimens are first shot blasted and pickled in a 45 pct conc HNO_3, 3-10 pct HF solution in water and the welding is done in a chamber that has been evacuated to less than 3×10^{-4} mm Hg and then back-filled with high purity argon (24 ppm O_2 and 8 ppm nitrogen impurities) to 160 mm Hg welding pressure (*3*). The corrosion resistance of the welds is related to the nitrogen content of the welding chamber atmosphere, 100 ppm being sufficient to cause enhanced corrosion of specimens tested in the 'as-welded' condition (*4*). The effect of the nitrogen content of the welding chamber atmosphere on the corrosion resistance of Zircaloy-2 welds in 325°C water is shown in fig 2. However, it is possible to restore the corrosion resistance of arc melted Zircaloy-2 (low carbon) welds made in poor atmospheres or in atmos-

**An alloy of zirconium with 1·2-1·7 pct Sn; 0·07-0·20 pct Fe; 0·05-0·15 pct Cr; and 0·03-0·08 pct Ni.*

pheres deliberately contaminated with up to 800 ppm nitrogen by post weld shot blasting and pickling (*4*).

Butt welds have been made in large tubes of American Zircaloy-2 using filler metal but without a controlled atmosphere chamber such that the tube interiors were free from corrosion after 6 months in 350°C deionized water (*5*). The tube surfaces were simply degreased, the end wire

Fig 2 Effect of nitrogen content of the welding atmosphere on the corrosion resistance of Zircaloy-2 butt welds in 325°C water. Nitrogen contents are, left to right, 100, 200, 400 and 1000 ppm

brushed before welding and the welds were not surface treated. Argon flowing from the torch protected the tube exterior while the interior was protected by helium flowing through a copper backing plug .

These two differing sets of conditions established for welding Zircaloy-2 are due either to higher purity material being used in the USA or to faster weld cooling rates and consequently less superficial contamination in the latter investigation, or to a combination of both.

Multipass welds in Zircaloy-2 plate, made in a helium atmosphere in a chamber initially evacuated to less than 0·03 microns, are ductile and have good corrosion resistance in 360°C water and 400°C steam (*6*). However, precipitates of intermetallic compounds in the root pass of a multipass weld in Zircaloy-2 give rise to lowered bend ductility and tension impact strength (*7*). The amount of precipitate is a function of the cooling rate but the embrittlement can be removed by post-weld heat-treatment at 870°C and quenching.

Resistance welding appears to be an attractive process for welding zirconium and its alloys as the problem of atmospheric contamination may not be serious because the weld is localized and of short duration. Sound joints have been made in zirconium (*8*) and Zircaloy-2 (*3, 4*) using projection welding techniques without inert gas shielding. If the superficial contamination formed during welding is removed by shot blasting and pickling, Zircaloy-2 welds have good corrosion resistance in 325°C water (*3, 4*). Quantitative data on the resistance welding of zirconium and Zircaloy-2 cannot be given since most of the work has been done on special shapes.

NIOBIUM

Niobium is of interest for atomic energy purposes because of its high melting point, excellent compatibility with uranium, good creep resistance and resistance to corrosion by pure alkali liquid metals. These properties together with a low capture cross-section for fast neutrons make niobium a potential canning material for fast reactors cooled by liquid metals (*9*).

The metal reacts slowly with air at temperatures as low as 200°C. The low-temperature, thin, adherent oxide film diffuses rapidly throughout the metal at elevated temperatures and this leads to embrittlement. Niobium containing below 40 ppm oxygen is resistant to attack by pure sodium-potassium alloy and with pure sodium at temperatures well above 800°C, but by analogy with the behaviour of tantalum it is expected that severe attack would occur in these media if the oxygen content of the metal exceeded 700 ppm.

Niobium sheet (0·012 to 0·030 in. thick) has been butt welded using the modified argon-arc welding technique described above for zirconium (*1*). The hardness of the weld in work-hardened sheet was comparable to that of annealed parent sheet, but on annealing at 1000°C in a vacuum the surface oxide film formed during welding diffused rapidly into the metal with consequent hardening of the weld bead and heat-affected zone.

More effective shielding of the weld areas is obtained by argon-arc welding in a dry box or in a vacuum chamber (*10*). The dry box was purged with 99·997 pct pure argon for five minutes and the flow maintained during welding and until the specimen was cold. The chamber was evacuated to $< 1 \times 10^{-4}$ mm Hg for 20 minutes and then back-filled with argon to a pressure of 250 mm Hg. Lap, butt and edge welds were made in 0·020 to 0·050 in. thick tubes, after degreasing and wire brushing, under the conditions given in table II. Ductile welds were produced by both methods but more consistent results as regards weld ductility were obtained using the vacuum rig. Joints made in the dry box fractured at the weld in tensile tests, whereas those made in the vacuum chamber broke in the tube away from the weld area.

TABLE II

Argon-arc welding data for niobium (10)

tube thickness (in.)	joint type	open circuit volts	welding current (amps)	current type	electrode size (in.)	gas flow (litres/min)
0·010	lap	60	27-28	—d.c.	$\frac{1}{16}$	10
0·020	lap	60	45-50	—d.c.	$\frac{3}{32}$	10
0·020	edge	110	45-54	a.c.	$\frac{1}{8}$	10
0·030	butt	50	40-45	—d.c.	$\frac{1}{8}$	10
0·030	butt	110	45-48	a.c.	$\frac{1}{8}$	10

Resistance welding may be used for joining sheets which are too thin to be argon-arc welded. Spot welding can be made in air providing the weld time is restricted to one or two cycles but seam welding is preferably carried out under water (*11*). The function of the water is to remove heat from the weld as quickly as possible, thus keeping the time the metal is hot to a minimum. Quantitative data for seam welding has been published (*11*) but it should be emphasized that electrical measurements on resistance welding equipment can only be considered approximate.

BERYLLIUM

Beryllium is an attractive material for atomic reactors because of its low capture cross-section for thermal neutrons and reasonable strength and oxidation resistance up to 600°C. Unfortunately, these properties are offset by difficulties in fabrication, particularly welding. The welding of beryllium poses a number of problems because of its brittleness in certain directions after working and the fact that rapid oxidation and grain growth occur at fusion welding temperatures. In addition, the toxic hazard associated with solid beryllium becomes aggravated at temperatures above 700°C and the welder must be protected from airborne oxide particles.

Both metallic arc (*12*) and atomic hydrogen (*13*) welding, with and without fluxes, have been unsuccessful but greater success has been achieved by tungsten-arc welding in an argon atmosphere using both a.c. and d.c. power (*14*). The refractory nature of the oxide makes it difficult to obtain a fluid melt but a considerable amount of 'cleaning' takes place with d.c. reverse polarity (electrode positive) and with a.c. on the positive half cycle. Fully fused edge and butt welds can be made by a.c. argon-arc weld-

ing of tube and sheet without filler metal (*14*). Weld cracking was not obtained although there was a tendency in some instances for cracks to be formed in the heat-affected zones.

An electronic welding process has been developed for the fusion welding of beryllium, zirconium, niobium and many other reactive and refractory metals (*15*). In this process, a tungsten filament electron source and an adjustable focusing system are placed above the work-piece in a vacuum chamber. The electron energy dissipated is sufficient to melt the metal and makes possible many different kinds of joints in vacuo. The beam has to be interrupted regularly to prevent metallic vaporization and this also avoids excessive grain growth in beryllium.

The coarse grains and low strength and ductility associated with the cast structure of the weld bead in fusion welding processes can be avoided by solid-phase pressure welding techniques. A wide range of pressures and temperatures can be employed. Diffusion welding, in which no pressure is applied, is achieved by heating cleaned surfaces of beryllium together at 1200°C for upwards of two hours (*12*). Upsetting of beryllium rods at 850°C under a pressure of 5 ton/sq. in. gives a joint strength of 20 ton/sq in. (*16*). As is general with pressure welding techniques, relative movement of the two surfaces whilst held in intimate contact is essential to attain satisfactory joints.

In designing joints for all types of welding processes, due care must be paid to the mechanical properties of the beryllium used or restraint may lead to cracking of the base metal as well as the weld material.

URANIUM

Uranium can be fabricated by most of the processes developed for the more common metals but its pyrophoric nature and tendency to oxidize rapidly when heated in air complicate welding operations. Although welding has not been used in the fabrication of uranium for nuclear powered reactors, it has been considered as a possible process for producing long fuel elements.

Of several methods investigated for fusion welding the most satisfactory is the inert gas, shielded arc process (*17, 18*). The surface oxide films on the uranium were removed electrolytically using an aqueous solution containing 70 pct by volume sulphuric acid and 5 grams per litre of chromic acid, or by machining prior to welding. The oxide film present on previously cleaned uranium was not detrimental to the production of sound welds. Weldments were made in an inert gas blanket using straight polarity direct current and a thoriated tungsten electrode. The weld area was shielded by helium flowing from the torch at 30 cu ft/h and the undersurface by helium flowing at 10 cu ft/h. Manual and automatic welds were made in sheet

TABLE III
Helium-arc welding data for uranium (18) d.c. straight polarity.

sheet thickness (in.)	welding current (amps)	open circuit volts	welding speed (in./min)
0·010	7	26	40
0·020	16	23	40
0·030	27	50	40
0·040	40	18	33
0·060	50	19	33
0·080	66	20	33

0·01 to 0·25 in. thick, with complete penetration and freedom from porosity, cracks and oxide inclusions. The tensile and yield strengths of the welded joints exceeded those of cast material but the elongation was lower. Some distortion occurred in the weldments but residual stresses were insignificant. Welding had to be done in the downhand position as the high density and fluidity of the melt made overhead and vertical welding impossible. The conditions for welding uranium sheet are given in table III.

Butt welds made in 0·05 and 0·10 in. thick sheet by the automatic argon-arc technique in a total atmosphere of purified argon were not severely oxidized but porosity was sometimes observed at the root of the welds due to mechanical entrapment of argon (*19*). Similar joints made in air with a backing plate drilled to provide argon coverage were heavily oxidized.

Butt welds have been made in $\frac{1}{4}$ and 1 in. thick plates by manual argon-arc welding, without and with filler rod respectively (*19*). Lack of penetration into the parent plate was overcome by pre-heating the joint by traversing with a low current arc. Fig 3 shows a macrostructure of an argon-arc weld with uranium filler rod.

Metallic arc (*19*) and *Sigma* (*17*) welding techniques have been applied to the joining of uranium with some success, and sheet 0·01 to 0·40 in. thick, can be readily argon-arc spot welded (*18*) (*19*).

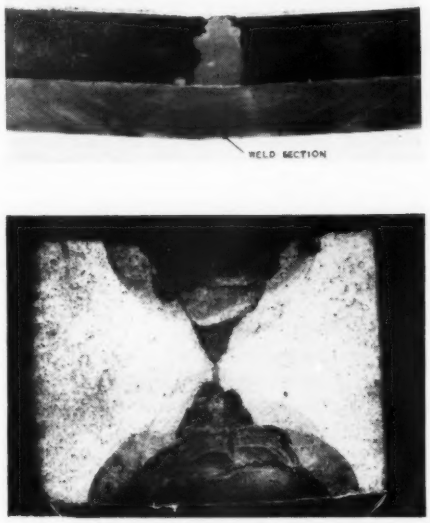


Fig 3 Macrostructure of multilayer weld in 1 in. uranium plate (Gough and Roberts)

Resistance spot welds have been made in sheet up to 0·1 in. thick without difficulty providing the faying edges were well cleaned prior to welding (*10*) (*19*). The welds were made in air and were not heavily oxidized.

Fig 3 is reproduced by permission of the *British Welding Journal*

References

1. Cox, F. G., *Murex Review*, 1952, *1*, p 245; *ibid*, 1956, *1*, 429
2. Treco, R. M., Murray, G. T., and French, R. S., *USAEC Report*, BRB-1, Jan 1955
3. Purchas, J. G., Harries, D. R., and Cobb, H., *British Welding Journal*, 1957, *4*, p 412
4. Purchas, J. G., Harries, D. R., and Cobb, H., *AERE Harwell Report*, to be published
5. Lingafelter, J. W., *Welding Journal*, 1957, *36*, p 230
6. Johnson, R. E., and Schaaf, B. W., *Welding Journal*, 1958, *35*, 1–S
7. Niemann, J. T., and Sopher, R. P., *Welding Journal*, 1956, *35*, 27–S
8. Lustman, B., and Kerze, F., *Metallurgy of zirconium*, McGraw-Hill, New York, 1955
9. McIntosh, A. B., and Bagley, K. Q., *J Inst Metals*, 1955-56, *84*, p 251
10. Taylor, A. F., and Stockdale, J. F., *UKAEA Report* IGR-TN/S-439, Feb, 1957
11. Cox, F. G., *Welding and Metal Fabrication*, 1956, *24*, p 352
12. White, D. W., and Burke, J. E., *The Metal Beryllium*, ASM, 1955
13. Creutz, E., and Gurinsky, D., *Metal Progress*, 1952, *62*, p 82
14. Purchas, J. G., and Darwin, E. R., *AERE Harwell Report*, to be published
15. Stohr, J. A., *Fuel Elements Conference*, Paris, November, 1957
16. Munro, W., Private communication
17. Nelson, V. G., Taub, J. M., and Doll, D. T., *USAEC Report* LA 1449, August, 1952
18. Brundige, E. L., Doll, D. T., Hanks, G. S., and Taub, J. M., *Nuclear Metallurgy*, 1957, *4* (Nov) p 107
19. Gough, J. R. C., and Roberts, D., *British Welding Journal*, 1957, *4* p 393

Corrosion and heat resisting steel fabrication

J. A. McWILLIAM, TD, MA(Cantab), MInstW

Firth-Vickers Stainless Steels Ltd

IT IS ESSENTIAL for the designers, fabricators, and users of corrosion- and heat-resisting steels to realize that there are many different analyses from which a choice can be made. Drawings and enquiries are still frequently sent out with the words 'stainless steel', or sometimes '18/8 stainless steel' opposite certain items. It is essential to specify the exact grade of steel required. If the designer does not know which steel to use for any particular job he should consult the steel manufacturers. The leading manufacturers of stainless steels have accumulated considerable experience over many years, and are usually able to advise on a particular steel to meet the required conditions.

The choice of any particular analysis depends first of all on whether the steel will stand up to the corrosive conditions, and secondly whether it is suitable for the method of fabrication. Welding is frequently employed in fabricating these steels, and if so it is necessary to choose a suitable analysis.

Table I shows typical analyses of some of the martensitic and ferritic types of corrosion- and heat-resisting steels.

TABLE I

	FI pct	FI (low C) pct	FI (Al) pct	FG pct	FI 20 pct
carbon	0·10	0·07	0·07	0·25	0·06
silicon	0·30	0·30	0·70	0·30	0·30
manganese	0·50	0·50	0·50	0·50	0·70
chromium	13·0	12·5	12·5	13·0	21·0
aluminium	—	—	0·25	—	—

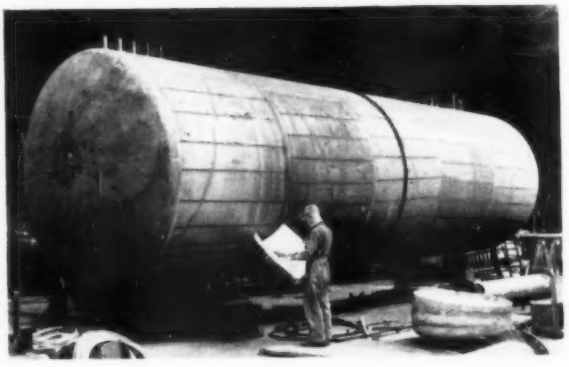
These steels are all strongly ferromagnetic compared with the austenitic types described later which are essentially non-magnetic. The FI steel, containing 13 pct Cr and 0·10 pct C, can be welded using pre-heat and post-heat. The reason for using both pre-heat and post-heat is that the steel is fairly strongly air-hardening, and the pre-heat lessens the chilling effect of the cold metal adjacent to the weld and the post-heat treatment will temper the hardened zone. The pre-heat is usually at 200-300°C, and the post-heat treatment at 700-750°C, allowing at least an hour per inch of thickness after the tempering temperature has been reached. It must always be remembered that these steels have a lower thermal conductivity than carbon steels and require much longer time for the heat to soak through.

The lower carbon types have less tendency to harden adjacent to the welds, and by reducing the carbon to 0·07 pct maximum, pre-heat and post-heat can be dispensed with although it is safer to use them if possible. A similar steel with carbon 0·05 pct max can now be supplied. In the USA the American Iron and Steel Institute type 405 steel has low carbon, and a small addition of aluminium added to lessen the tendency to air harden. Some years ago the writer carried out tests to determine the best standard electrode for the metal arc-welding of low carbon 13 pct chromium steels. Best results were obtained using 25 pct Cr/17 pct Ni electrodes. A tensile test across a weld of this type gave, after heat treatment, a yield point of 26 ton/sq in., and a maximum stress of 35·5 ton/sq in., with an elongation of 35 pct.

The FG quality has such a strong tendency to air harden owing to its higher carbon that there is a danger of cracking near a weld, and therefore welding is not recommended. There is no hard and fast distinction between corrosion- and heat-resisting steels; in fact all the steels already mentioned are good for resisting scaling up to 700°C.

Austenitic steels

Table II shows the analyses of some of the many austenitic Cr/Ni steels which are produced today. The FST type was first produced about 1924 and is the basis of the well known 18/8 group of steels. As well as a substantial percentage of chromium it also contains 8·5 pct Ni, and like the other austenitic steels, it is practically non-magnetic. It is, however, not desirable to use this as a heat resisting steel because if it is heated in the range of 450-850°C, carbide precipitation takes place in the vicinity of the grain boundaries with the formation of chromium carbide, with an analysis approximating to Cr_4C. The effect of this is



This storage tank for radioactive liquors was fabricated for the UKAEA from 18/12/1 Nb steel. All welds were X-ray inspected

that a small amount of carbon 'locks up' a large amount of chromium and renders it useless from the point of view of resistance to corrosion. This leads to chromium impoverishment at the crystal boundaries and renders the

TABLE II

	FST pct	FSL pct	FDP pct	FCB pct	18/12/1 pct	FMB pct	Imm. 5 pct
carbon	0·10	0·05	0·10	0·08	0·10	0·07	0·14
silicon	0·60	0·60	0·80	0·60	0·60	0·30	1·36
manganese	0·80	0·80	0·80	0·80	1·5	0·80	0·80
chromium	18·0	18·50	18·0	18·0	18·0	18·0	24·35
nickel	8·50	10·0	9·0	9·50	12·0	9·50	21·5
titanium	—	—	0·60	—	—	—	—
molybdenum	—	—	—	—	—	2·75	—
niobium	—	—	—	0·90	0·90	—	—

steel susceptible to intercrystalline corrosion. This can be so severe that the material may quite quickly disintegrate and in fact the phenomenon is sometimes referred to as disintegration. The disintegration can be caused even by mild corrosive conditions. It is clear that when a weld is made on this steel, the material on either side of the weld is heated in the temperature range 450-850°C and thus may be made susceptible to intercrystalline corrosion, or 'weld-decay' as it is sometimes called, although as the trouble usually occurs outside the weld, the term is rather a misnomer.

With the FSL quality, the carbon is kept to 0·05 pct

In argon-arc welding on 18/12/1 Nb steel, the first run is usually made without filler. Subsequent runs are then laid down using 18/9/1 Nb electrodes

maximum, and this is safe for use in the as-welded condition. However, this steel should not be used as a heat-resisting steel operating at temperatures above 300°C as otherwise chromium carbide might be formed and the corrosion-resistance impaired. The most potent stabilizing element to prevent the formation of chromium carbide is titanium and in FDP the titanium content is at least four times that of carbon. This steel is the most commonly used of the 18/8 steels for welded fabrication.

In the FCB quality it will be seen that the stabilizing element is niobium, and this has a niobium content at least eight times the carbon content. Recently the increased availability of niobium has resulted in more being used in place of titanium. This is particularly desirable in heavy bar and forgings where titanium inclusions may appear in the form of stringers. The niobium-bearing steels are rather more expensive than the titanium-bearing ones, and if this had not been the case they would have replaced them. Niobium stabilized 18/8 steels began to come into general use in the USA in 1938 and they found an immediate application in the production of metal arc-welding electrodes. Prior to this time the 18/8 Ti electrodes had always shown a considerable loss of Ti in the arc and the result of this was that while the plate on either side of the weld was safe against intercrystalline corrosion, the weld metal itself was lacking in titanium and therefore susceptible to intercrystalline corrosion. This was particularly noticeable in multi-run welds where the additional runs heated up the earlier ones in the 450-850°C range and so rendered them susceptible. Using niobium stabilized electrodes the weld deposits are safe against intercrystalline corrosion because only a small percentage of the niobium is lost in the arc. Niobium-bearing filler wire also finds extended use in argon-arc welding and *Sigma* welding shielded inert gas metal arc) and also in oxy-acetylene welding.

The steel commonly referred to as 18/12/1 steel is made to UKAEA 70003C. This steel is fully austenitic and while single run welds present little difficulty, in welds with more than one run there is a danger of hot cracking. This is liable to be hidden by the last run of weld metal and for this reason may be more dangerous. Where it is desirable to have the weld metal of as near as possible identical composition in contact with the corrosive media, it is customary to make the first run by argon arc without filler; the subsequent runs can then be laid down using electrodes of the 18/9/1 Nb type. This latter gives a weld deposit of duplex structure which is not susceptible to hot fissuring and results in the complete weld being sound.

Immaculate 5 steel is also fully austenitic and here again in heavy welds there is the risk of hot cracking if an attempt is made to leave a fully austenitic weld deposit. As this steel is mostly used for resistance to high temperatures above 800°C, the weld deposit must also have good scale resisting properties. It is possible to lay down the first run using a 25Cr/17Ni electrode and make subsequent runs with an electrode depositing 24Cr/12Ni/3W. This latter gives a duplex structure and so gets over the danger of hot cracking.

FMB and FMBTi quality

It will be noticed that the FMB quality contains about 2·75 pct Mo and the C is 0·07 pct max. This steel has a higher resistance to certain corrosive conditions than the other steels shown in this table and it is particularly useful in contact with chloride solutions and dilute sulphuric acid. It is safe for use in the welded condition without heat treatment. However, during a hot working operation such as the manufacture of a hot forging or the hot pressing of a dished end of a vessel, the steel might be long enough in the 450-850°C range of temperature to form chromium carbide and render the steel susceptible to intercrystalline corrosion. Therefore, after hot working it is essential to heat the item concerned to 1050°C, soak for ½ hour after the heating has soaked through and then cool quickly, preferably by water quenching. There is a modification of FMB known as FMBTi, in which Ti is added. While this analysis is safe against carbide precipitation, it can be susceptible to the formation of Sigma phase from delta ferrite if held in the range 550-900°C. It is therefore not desirable to use FMB or FMBTi as heat-resisting steels. The formation of Sigma phase does not impair the resistance to corrosion to most media and therefore the presence of the small quantity of this phase should not be allowed to cause too much worry, as there is no doubt that plant has been used in the past with Sigma phase present without giving any trouble.

No survey, however brief, of corrosion-resisting steel would be complete without reference to the new FV520 steel developed by Firth-Vickers Stainless Steels Ltd. For many years there has been a demand for a steel combining the resistance to corrosion of the 18/8 steels with good mechanical and welding properties. FV520 meets these requirements and is available as bar, castings, forgings, sheet and strip. It is a Cr/Ni steel with additions of Cu and Mo, and is hardened by heat treatment. While the earlier martensitic stainless steels are difficult to weld FV520 is readily welded, without special precautions to avoid cracks. The most usual method is argon-arc using FV520 filler wire. FV520 steel also has good resistance to stress corrosion, good creep strength up to 500°C, and very good Izod impact test values even down to minus 200°C.

Nondestructive testing for nuclear plant

F. S. DICKINSON, AMIMechE, AMInstW & E. J. KEEFE, BSc, MInstW

UKAEA Industrial Group, Risley

THE APPLICATION of nondestructive methods of test has perhaps been more extensive in nuclear engineering than in any other industrial enterprise. The reasons for this are not hard to find, since on the one hand a new and in many respects novel undertaking tends to demand that no chances are taken, whilst on the other, failures might not only have far reaching consequences but render repair even of localized areas impossible or extremely hazardous because of radioactivity. Thus the integrity of the welded joint must be guaranteed, and its system of inspection considered at the design stage, not after its execution.

Methods in use

The simplest examination, that by the unaided eye, is very often ignored and it is by no means a rare occurrence that expensive methods are applied to reveal defects which a careful preliminary scrutiny would have revealed. Visual examination of welded pipework for example can be readily carried out by means of an introscope. These instruments enable the bore of small vessels or pipes to be seen under low power magnification, and have been made up to 20 ft long and suitable for 1 in. dia pipe. They are invaluable tools for the positive assessment of the condition of the root bead of pipe welds which might otherwise cause either confusion or uncertainty if interpreted, for example, from the radiograph alone.

Radiography is used to a far greater extent than any other method, not because it is regarded as the supreme guarantee of quality, but because in addition to its accepted merits a permanent record of the joint as put into service is retained. Other methods require a much more complicated procedure, and no amount of copious description can quite replace the 'photographic' evidence. An indication of the extent to which radiography has been used on one plant alone can be gained from the fact that 5000 tons of welded plate, in addition to 50,000 pipe welds, were inspected during the building of the Windscale chemical separation plant. At peak construction 1000 gamma-graphs per week were taken.

Ultrasonic methods are not very often used for routine weld examination since the interpretation of the traces received does not enable the type of defect to be determined, although its location relative to the surface can be accurately obtained. However, the use of ultrasonic testing on thick material as a complement to radiography has much to commend it providing that confusion is avoided by not showing defects on the screen which cannot be subsequently seen on the radiograph. It is extremely useful in assessing the quality of material which may eventually comprise the welded joint, and its application in this direction is increasing. A specific example of its use is that of checking the quality of the magnesium alloy bar from which the Calder Hall fuel element cans are made.

Penetrant methods of detection are of course limited to surface faults, but they provide a very searching means of examination, particularly for cracks which, due to orientation or fineness, are not found by radiography. Apart from general applications, usually in conjunction with other nondestructive methods, penetrants have been used to check fillet welds in austenitic steels for which radiographic methods are poor and magnetic methods not applicable. There is some advantage in using a fluorescent system in which darkness is required since this removes the possible distraction of the general outlines of the welded component, and attention is confined solely to the weld in question.

Magnetic crack detection has an advantage over the penetrant methods since sub-surface as well as surface flaws can be revealed. Its limitation, apart from geometry and the depth of detection to which it can be safely used, is the restricted number of materials on which it is effective. However, since a considerable amount of welded fabrication is of ferrous nature, it can still be fairly widely applied and has proved useful for the examination of fillet welds on the supports for the Calder pressure vessels.

Testing for leaks

All the foregoing methods of test can take place at any stage of manufacture, but a final nondestructive pressure test, whether above or below atmospheric, is usually demanded. The simplest test for finding leaks is that of the air/soap and water method. This test does not receive the credit which is due to it, and ought to be applied as far as practicable before any vacuum work is attempted, since it will not only reveal large leaks immediately, but also quickly show those of a small order and save considerable time. Only the very slowest leaks are missed, and their extent as subsequently revealed by vacuum testing adds to the confidence with which one may apply a test reminiscent of that used on a punctured tyre.

Vacuum testing is extensively used and in some cases is the sole guarantee of the satisfaction of the welded seam. The general standards are that no leak shall exist which would cause a pressure rise exceeding 36 microns/hour when evacuated to a base pressure of 50 microns (1 micron $= 10^{-3}$ mm Hg). Higher standards are used for more exacting work, for example a maximum leak rate of 5 microns at a base pressure of 10 microns. This latter test is done using the charcoal-pirani technique in which the vessel under test is surrounded with a container filled with hydrogen, pumping taking place via a charcoal cold trap which will absorb all gas save hydrogen. Certain facts should be observed in design when vacuum testing is specified, and fig 1 indicates one cause of practical difficulty. A trapped volume exists between welds A and B whose geometry is such that if a leak is present in weld B the pumping time to the required vacuum would be considerable. Furthermore, the location of such a leak could not be found should weld A be sound. In circumstances where double fillet welds must be used, weld A could be made intermittent or have a hole drilled into its root

so that weld B could be checked by evacuation from the outside of the vessel. It is thus essential to design in such a manner that trapped volumes are avoided by either using complete penetration welds or considering the use of similar methods outlined above.

Although vacuum testing is extremely sensitive it is slow, and other forms of leak detection such as the nitrous oxide method are much quicker and do not sacrifice much sensitivity. The method consists of filling the test volume with N_2O at low pressure and then probing the weld surfaces. Leaks are then detected by the small quantity of

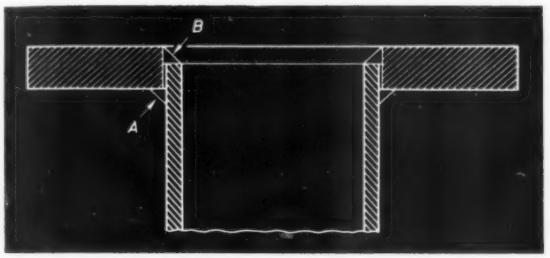


Fig 1 When vacuum testing is specified, trapped volumes, such as that between the welds A and B, must be avoided at the design stage

gas being lead off to an infra-red absorption gas analyser. This test has been used as an additional safeguard to check the leak tightness of the fast reactor primary cooling circuit containing upwards of 4000 previously radiographed butt welds. Details of the method are given by Griffiths (*1*).

Highly radioactive plant

It has already been mentioned that this type of plant is difficult, or even impossible, to repair, and for this reason the stringency of inspection is far greater than for the same plant operating under the same conditions, but without such potential hazard.

Chemical processing plant built from fully austenitic stainless steel has been and is still constructed to the most exacting requirements and the welds subjected to critical radiographic examination The technique used is always the X-ray method unless it is totally impracticable when gamma radiography using iridium-192 sources is permitted.

For welds functioning under direct corrosive conditions the design is such to allow butt welds to be made and inspected to a penetrameter sensitivity of 1 pct. A penetrameter is a device whereby the radiographic technique being applied is checked to ensure that defects of the desired order of smallness are being revealed. It may consist of a series of either graduated thickness wires or plates and is placed between the source of radiation and the object, being in intimate contact with the latter. It is normally made of the same material as that being radiographed and the clarity with which its image is shown on the film together with the amount of detail revealed is then used to assess the quality of the radiograph. The sensitivity can normally be obtained from the ratio:

$$\text{sensitivity (pct)} \frac{\text{thinnest portion of penetrameter}}{\text{total thickness of material at this point}} \times 100$$

TABLE I

Recommended kV and object/source distances for radiography

material thickness	recommended kilovoltage	recommended object/film dist
$\frac{1}{4}$ in.	110/115	24 in.
$\frac{1}{2}$ and $\frac{3}{4}$ in.	150	30 in.
over $\frac{3}{4}$ up to $1\frac{1}{4}$ in.	220	36 in.

The penetrameters of a type illustrated in fig 2 have been experimentally developed for the three material thicknesses in most common use (i.e. $\frac{1}{4}$ in., $\frac{3}{8}$ in. and $\frac{1}{2}$ in.) such that when three of the four fine wires are visible the above sensitivity is being obtained. They were never intended to be a means of assessing the precise sensitivity under other conditions, and thus attempts to evaluate them arithmetically will prove misleading.

In order to obtain high quality radiographs certain conditions are observed, and recommended kilovoltages and object/source distances are given in table I. For material thicker than $\frac{1}{2}$ in. a step wedge type of penetrameter is used. Exposures are made of at least two minutes duration in conjunction with fine grain high contrast film and lead screening to result in a film density of upwards of 1·8.

When pipework is inspected, unless the diameter is large, a double wall technique must be used. This results in only half the sensitivity on the weld thickness being inspected, and it is thus accepted that only 2 pct will be obtained. For pipe less than 3 in. the double wall/double image method may be used, whilst for larger pipe the double

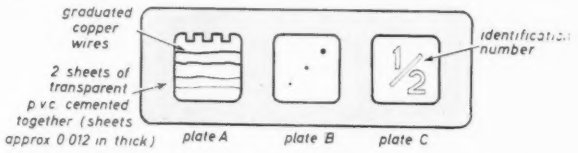


Fig 2 Penetrameter typical of those used for the three most commonly used material thicknesses, with plate dimensions and specifications

Plate A

size	thickness of base (spring steel) (in.)	graduation of copper wires s.w.g.	no. of notches
$\frac{1}{4}$ in.	0·002 $^{+0·001}_{-0·000}$	36, 38, 40, 42	1
$\frac{3}{8}$ in.	0·003 $^{+0·001}_{-0·000}$	35, 36, 38, 39	2
$\frac{1}{2}$ in.	0·004 $^{+0·001}_{-0·000}$	33, 34, 36, 38	3

Plate B

size	thickness of base (mild steel) (in.)	s.w.g.	size of holes jewellers	tolerance (in.)
$\frac{1}{4}$ in.	0·020 ±0·001	22, 25, 33	$7\frac{1}{2}$, 5, 3	±0·001
$\frac{3}{8}$ in.	0·028 ±0·001	22, 25, 33	$7\frac{1}{2}$, 5, 3	±0·001
$\frac{1}{2}$ in.	0·040 ±0·0015	22, 25, 33	$7\frac{1}{2}$, 5, 3	±0·001

Plate C

size	identity plate (mild steel) (in.)
$\frac{1}{4}$ in.	0·020 ±0·001
$\frac{3}{8}$ in.	0·028 ±0·001
$\frac{1}{2}$ in.	0·040 ±0·0015

wall/single image technique must be applied. Fig 3 and 4 illustrate these two methods. It is on pipework that gamma radiography can be economically used, since a short object/source distance will keep exposure times to reasonable level. Circumstances in which X-ray heads could not be manipulated to cover all the welds, and where gamma radiography was used are illustrated on p. 207.

Acceptance standards

Unlike other inspecting authorities, a standard of acceptance is defined by the AEA to which the radiographs are interpreted, and the following illustrates the high quality of workmanship demanded. It is appreciated of course that one cannot describe every circumstance of defect likely

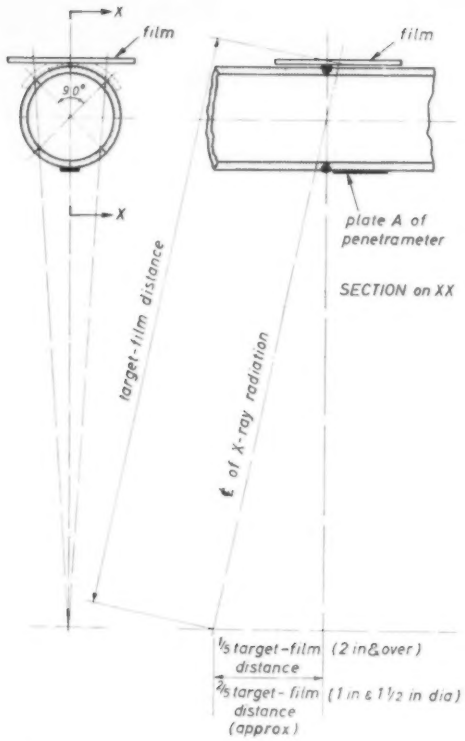


Fig 3 In radiographic inspection of pipe less than 3 in. the double wall/double image technique must be used . . .

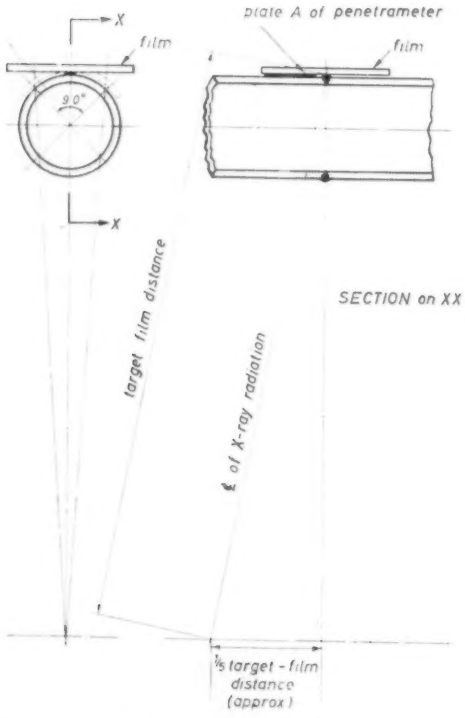


Fig 4 . . . while the double wall/single image method is applied on pipe greater than this

to be revealed, and in some cases discretion and common sense have to be exercised.

Unacceptable defects are:

1. cracks
2. incomplete penetration
3. lack of fusion
4. slag inclusions, except non-angular ones not exceeding the limits given for gas pores
5. undercut on either surface of the vessel
6. piping—this constitutes a globular defect with a well defined tail, i.e. a 'tadpole.'
7. porosity displaced or in groups in excess of the limits stated below.

Acceptable defects are:

a. Isolated gas pores and globular inclusions up to $\frac{1}{32}$ in. dia in any portion of the weld

b. Isolated gas pores and globular inclusions from $\frac{1}{32}$ in. to $\frac{1}{16}$ in. dia in the outer half of the weld

In these two cases 'isolated' includes not more than four pores separated from each other by at least four times their diameter. There may not be more than four acceptable defects in any one length of 12 in. The relaxation given is intended for butt welds but also applies to branch welds, which in addition may contain small slag inclusions if these occur at the junction of the shell plate and backing ring.

These acceptable defects relate to material thickness over $\frac{1}{4}$ in. up to and including $\frac{1}{2}$ in. For other thicknesses, the following applies:

Up to and including $\frac{1}{8}$ in. each case is considered on its merits.

Over $\frac{1}{8}$ in. up to and including $\frac{1}{4}$ in. defects in excess of $\frac{1}{32}$ in. dia are unacceptable.

Over $\frac{1}{2}$ in. up to and including $\frac{3}{4}$ in., up to $\frac{1}{16}$ in. dia on the inner half of plate thickness relaxing to $\frac{3}{32}$ in. dia on the outer half of the plate thickness.

For plate in excess of $\frac{3}{4}$ in. thickness each case is considered on its merits.

In material $\frac{3}{8}$ in. thick or less it may not be considered worthwhile to take a tube shift to determine the position of a defect, but in thicker material or where a backing ring is used it is an invaluable method.

Interpretation of results

The interpretation of the radiographic evidence can perhaps lead to more argument than in any other form of nondestructive examination, and considerable care should be exercised in arriving at a decision. It is essential when making the assessment to be in a position to look at the actual welded joint so that surface marking can be correctly identified. It is well to remember that radiography is an expensive method of test, and that full value should be obtained from the evidence presented. Thus examination should not be confined to the weld seam alone since defects in the parent plate are not unknown, even at this late stage of fabrication.

The maintenance of the high weld quality generally demanded in nuclear energy applications is a tribute to the manufacturers and contractors who work towards its upkeep. It can be argued that the standards required are unnecessarily high but it is important to realize that unless an initially high quality is aimed for in a new enterprise it is extremely difficult to build up to it afterwards and might have unfortunate psychological effects until a satisfactory state is established.

Acknowledgments
Thanks are due to Sir Leonard Owen, Managing Director, and to Dr. H. Kronberger, Director of Research and Development of the UKAEA Industrial Group for permission to publish this article.

Reference

1. Griffiths, S. H., 'Welding of heat-exchanger elements in a fast breeder reactor,' *British Welding Journal* 4 (9)

The Welding Industry

A Buyer's Guide

The successful exploitation for peaceful purposes of the energy available from the fission of uranium depends above all things on our being able to carry it out with complete security for the operatives and the public. To this end, nothing is more important than welding and the rapid progress now being achieved on Britain's nuclear power programme reflects in no small measure the powerful backing which the Atomic Energy Authority and the main constructional groups have received from the welding industry. In the future, with more advanced fission reactors already on the drawing boards and the as yet only speculated problems arising from thermonuclear reactors the welding industry will be called upon even further to ensure that these plants will be operated with the highest standards of safety and efficiency.

The welding industry is a highly specialized one and this NUCLEAR POWER *special feature has been compiled to give potential buyers a convenient and rapid guide to its many facets.*

Blowpipes
- Acetylene Generator & Tool Co Ltd (cutting and welding)
- Baddeley Engineering Co Ltd, D. S.
- British Industrial Gases Ltd
- British Oxygen Gases Ltd
- Centrajet Ltd (Cutting nozzles)
- Oxhycarbon Co Ltd
- Pollock & Peel Ltd (cutting nozzles)
- Saturn Industrial Gases Ltd
- Suffolk Iron Foundry (1920) Ltd
- Young & Co Ltd, A. S.

Brushing equipment
- Baddeley Engineering Co Ltd, D. S.
- Dendix Brushes Ltd
- Gem Brushes (Luson) Ltd

Electrodes
- Arc Manufacturing Co Ltd
- British Insulated Callender's Cables Ltd
- Cooper & Turner Ltd
- Deloro Stellite Ltd
- Eutectic Welding Alloys Ltd
- Fuller Electric Ltd
- Lincoln Electric Co Ltd
- Metropolitan-Vickers Electrical Co Ltd
- Murex Welding Processes Ltd
- Quasi-Arc Ltd
- Rediweld-Oerlikon Electrodes Ltd
- Rockweld Ltd
- Sciaky Electric Welding Machines Ltd
- Siebe, Gorman & Co Ltd (underwater welding and cutting)
- Welding Supplies Ltd

Electrode holders
- Arc Manufacturing Co Ltd
- Baddeley Engineering Co Ltd, D. S.
- Lincoln Electric Co Ltd
- Metropolitan-Vickers Electrical Co Ltd
- Murex Welding Processes Ltd
- Quasi-Arc Ltd
- Rediweld-Oerlikon Electrudes Ltd
- Rockweld Ltd
- Ross & Partners Ltd, Donald
- Siebe, Gorman & Co Ltd
- Welding Supplies Ltd
- Young & Co Ltd, A. S.

Fluxes
- Baddeley Engineering Co Ltd, D. S.
- British Industrial Gases Ltd
- British Oxygen Gases Ltd
- Eutectic Welding Alloys Ltd
- Fuller Electric Ltd
- Lincoln Electric Co Ltd
- Sheffield Smelting Co Ltd, The
- Suffolk Iron Foundry (1920) Ltd
- Welding Supplies Ltd
- Young & Co Ltd, A. S.

Gases
- British Industrial Gases Ltd
- British Oxygen Gases Ltd (oxygen, acetylene, nitrogen, argon, propane, hydrogen, coal gas, compressed air)
- Imperial Chemical Industries Ltd (argon)
- Saturn Industrial Gases Ltd (propane, argon)

Gas regulators
- Acetylene Generator & Tool Co Ltd
- Baddeley Engineering Co Ltd, D. S.
- British Industrial Gases Ltd
- British Oxygen Gases Ltd
- Oxhycarbon Co Ltd
- Saturn Industrial Gases Ltd
- Siebe, Gorman & Co Ltd
- Suffolk Iron Foundry (1920) Ltd
- Young & Co Ltd, A. S.

Goggles
- Acetylene Generator & Tool Co Ltd
- Arc Manufacturing Co Ltd
- Baddeley Engineering Co Ltd, D. S.
- British Industrial Gases Ltd
- British Oxygen Gases Ltd
- Fleming Ltd, J. & R.
- Lincoln Electric Co Ltd
- Metropolitan-Vickers Electrical Co Ltd
- Murex Welding Processes Ltd
- Quasi-Arc Ltd
- Safety Products Ltd
- Siebe, Gorman & Co Ltd
- Suffolk Iron Foundry (1920) Ltd
- Welding Supplies Ltd
- Young & Co Ltd, A. S.

Grinding equipment
- Anglo Abrasives Ltd
- Flextol Eng Co Ltd
- Neill & Co (Sheffield) Ltd, James
- Norton Grinding Wheel Co Ltd
- Ross & Partners Ltd, Donald
- Saturn Industrial Gases Ltd
- Turret Grinding Wheel Co Ltd

Grit and shot-blasting equipment
- Berk & Co Ltd, F. W.—Schori Division
- BTR Industries Ltd
- Curtis & Co Ltd, A. L.
- Eutectic Welding Alloys Ltd
- Guyson Industrial Equipment Ltd
- Metallising Equipment Co Ltd
- Vacu-Blast Ltd

Helmets
- Arc Manufacturing Co Ltd
- Baddeley Engineering Co Ltd, D. S.
- Fleming Ltd, J. & R.
- Fuller Electric Ltd
- Lincoln Electric Co Ltd
- Metropolitan-Vickers Electrical Co Ltd
- Murex Welding Processes Ltd

Quasi-Arc Ltd
Rediweld-Oerlikon Electrodes Ltd
Siebe, Gorman & Co Ltd
Welding Supplies Ltd
Young & Co Ltd, A. S.

Magnetic crack detection equipment
Metropolitan-Vickers Electrical Co Ltd
Welding Supplies Ltd

Motor generator sets
Fuller Electric Ltd
Lincoln Electric Co Ltd
Metropolitan-Vickers Electrical Co Ltd
Murex Welding Processes Ltd
Newman Industries Ltd
Petbow Ltd
Quasi-Arc Ltd
Rediweld-Oerlikon Electrodes Ltd
Welding Supplies Ltd
Young & Co Ltd, A. S.

Positioners
Bode & Son Ltd, F.
Courtburn Positioners Ltd
Metropolitan-Vickers Electrical Co Ltd
Neill & Co (Sheffield) Ltd, James
Quasi-Arc Ltd
Ross & Partners Ltd, Donald
Yates Plant Ltd

Preheating equipment
Acetylene Generator & Tool Co Ltd
Baddeley Engineering Co Ltd, D. S.
British Industrial Gases Ltd
British Oxygen Gases Ltd
Fuller Electric Ltd
Metropolitan-Vickers Electrical Co Ltd
Oxhycarbon Co Ltd
Quasi-Arc Ltd
Saturn Industrial Gases Ltd

Profile cutting machines
Baddeley Engineering Co Ltd, D. S.
British Industrial Gases Ltd
British Oxygen Gases Ltd
Hancock & Co (Engineers) Ltd
Oxhycarbon Co Ltd
Welding Supplies Ltd

Projection welding machines
Electro Mechan-Heat Ltd
Fuller Electric Ltd
Hirst Electronic Ltd
Meritus (Barnet) Ltd
Metro-Cutanit Ltd (dies and electrodes)
Metropolitan-Vickers Electrical Co Ltd
Sciaky Electric Welding Machines Ltd
Soag Machine Tools Ltd

Radiography equipment
Gamma-Rays Ltd
Ilford Ltd (Accessories)
Kodak Ltd
Marconi Instruments Ltd (X-ray equipment)
Metal & Pipeline Endurance Ltd (inspection service)
Metropolitan-Vickers Electrical Co Ltd
Palmer Aero Products Ltd (x-ray inspection service)
Pantak Ltd
Welding Supervision Ltd (inspection service)
Welding Supplies Ltd

Rectifiers
Arc Manufacturing Co Ltd
Baddeley Engineering Co Ltd, D. S.
British Oxygen Gases Ltd
Crompton Parkinson (Stud Welding) Ltd
Hackbridge & Hewittic Electric Co Ltd
Meritus (Barnet) Ltd
Metropolitan-Vickers Electrical Co Ltd
Murex Welding Processes Ltd
Quasi-Arc Ltd

Rods
Aluminium Wire & Cable Co Ltd
Arc Manufacturing Co Ltd
Baddeley Engineering Co Ltd, D. S.
British Industrial Gases Ltd
British Oxygen Gases Ltd
Deloro Stellite Ltd
Eutectic Welding Alloys Ltd
Sheffield Smelting Co Ltd, The
Suffolk Iron Foundry (1920) Ltd
Young & Co Ltd, A. S.

Safety equipment
Murex Welding Processes Ltd
Siebe, Gorman & Co Ltd (respirators)
Welding Supplies Ltd

Seam welding machines
Bode & Son Ltd, F.
Electro Mechan-Heat Ltd (electronic and control equipment)
Fuller Electric Ltd
Igranic Electric Co Ltd (contactor gear; inductive timers)
Lancashire Dynamo Electronic Products Ltd (control equipment)
Meritus (Barnet) Ltd
Metro-Cutanit Ltd (wheels)
Metropolitan-Vickers Electrical Co Ltd
Sciaky Electric Welding Machines Ltd
Soag Machine Tools Ltd
Welding Supplies Ltd
Young & Co Ltd, A. S.

Shielded-arc welding equipment
Arc Manufacturing Co Ltd
British Oxygen Gases Ltd
Metropolitan-Vickers Electrical Co Ltd
Quasi-Arc Ltd
Rockweld Ltd
Saturn Industrial Gases Ltd

Spot welding machines
A.I. Electric Welding Machines Ltd
Baddeley Engineering Co Ltd, D. S.
British Oxygen Gases Ltd
Electro Mechan-Heat Ltd (and electronic control equipment)
Fuller Electric Ltd
Hirst Electronic Ltd
Igranic Electric Co Ltd (control gear; inductive timers)
Lancashire Dynamo Electronic Products Ltd (control equipment)
Meritus (Barnet) Ltd
Metropolitan-Vickers Electrical Co Ltd
Sciaky Electric Welding Machines Ltd
Soag Machine Tools Ltd
Young & Co Ltd, A. S.

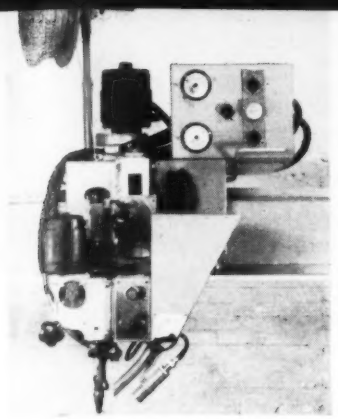
Spot welding tips
A.I. Electric Welding Machines Ltd
Baddeley Engineering Co Ltd, D. S.
Electro Mechan-Heat Ltd
Enfield Rolling Mills Ltd
Meritus (Barnet) Ltd
Metro-Cutanit Ltd
Metropolitan-Vickers Electrical Co Ltd
Young & Co Ltd, A. S.

Stud welding machines
Crompton Parkinson (Stud Welding) Ltd
Electro Mechan-Heat Ltd
Fuller Electric Ltd
Meritus (Barnet) Ltd
Sciaky Electric Welding Machines Ltd

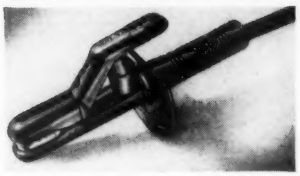
Submerged arc welding machines
Lincoln Electric Co Ltd
Metropolitan-Vickers Electrical Co Ltd
Quasi-Arc Ltd
Rediweld-Oerlikon Electrodes Ltd
Rockweld Ltd
Welding Supplies Ltd

Transformers
Arc Manufacturing Co Ltd
Baddeley Engineering Co Ltd, D. S.
British Oxygen Gases Ltd
Electro Mechan-Heat Ltd
Fuller Electric Ltd
Hirst Electronic Ltd
Hackbridge & Hewittic Electric Co Ltd
Meritus (Barnet) Ltd
Metropolitan-Vickers Electrical Co Ltd
Murex Welding Processes Ltd
Quasi-Arc Ltd
Rockweld Ltd
Welding Supplies Ltd
Young Co Ltd, A. S.

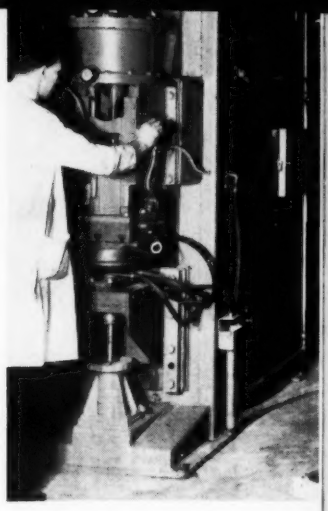
Ultrasonic inspection equipment
Kelvin & Hughes (Industrial) Ltd
Metal & Pipeline Endurance Ltd (inspection service)
Ultrasonoscope Ltd
Welding Supervision Ltd (inspection service)



LINCOLN ELECTRIC—automatic submerged arc welding head



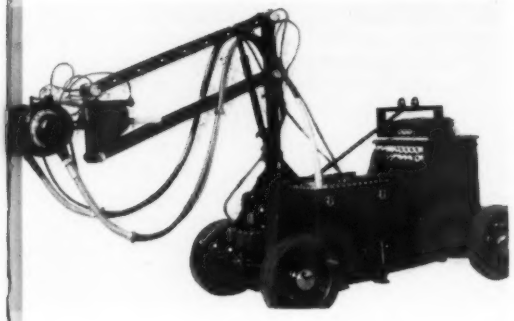
MUREX—insulated electrode holder



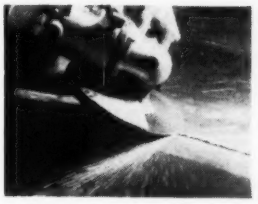
METROVICK—projection welder

BRITISH OXYGEN—Lynx carriage unit and rectifier

PANTAK—X-ray unit for reactor vessels



NORTON GRINDING—reinforced resinoid grinding wheel



ADDRESSES

of companies listed in buyers guide

ACETYLENE GENERATOR & TOOL CO LTD, 27 Howland St, London, W1
A.I. ELECTRIC WELDING MACHINES LTD, 68 Victoria St, London, SW1
ALUMINIUM WIRE & CABLE CO LTD, Port Tennant, Swansea
ANGLO ABRASIVES LTD, Alperton Lane, Wembley, Middx
ARC MANUFACTURING CO LTD, Actarc Works, Nitshill, Glasgow, SW3

BADDELEY ENGINEERING CO LTD, D. S., 43-45 York St, Glasgow, C2
BERK & CO LTD, F. W. (SCHORI DIV), Brent Crescent, North Circular Rd, London, NW10
BODE & SON LTD, F., Buxton Rd, Leek, Staffs
BRITISH INDUSTRIAL GASES LTD, 700 Gt Cambridge Rd, Enfield, Middx
BRITISH INSULATED CALLENDER'S CABLES LTD, 21 Bloomsbury St, London, WC1
BRITISH OXYGEN GASES LTD, Spencer Ho, St James's Pl, London, SW1
BTR INDUSTRIES LTD, Herga Ho, Vincent Sq, London, SW1

CENTRAJET LTD, Fossgate, York
COOPER & TURNER LTD, Vulcan Rd, Sheffield, 9
COURTBURN POSITIONERS LTD, Kempston Hardwick, Bedford
CROMPTON PARKINSON LTD, Crompton Ho, Aldwych, London, WC2
CURTIS & CO, A. L., Westmoor Laboratory, Chatteris, Cambs

DELORO STELLITE LTD, Highlands Rd, Shirley, Solihull, Warws
DENDIX BRUSHES LTD, Lower Church St, Chepstow, Mon

ELECTRO MECHAN-HEAT LTD, Lower Teddington Rd, Kingston, Surrey
ENFIELD ROLLING MILLS LTD, Brimsdown, Enfield, Middx
EUTECTIC WELDING ALLOYS CO LTD, North Feltham Trading Estate, Faggs Rd, Feltham, Middx

FLEMING LTD., J. & R., 146 Clerkenwell Rd, London, EC2
FLEXTOL ENGINEERING CO LTD, The Green, Ealing, W5
FULLER ELECTRIC LTD, Fulbourne Rd, London, E17

GAMMA-RAYS LTD, Foundry Lane, Smethwick, 40, Staffs
GEM BRUSHES (LUSON) LTD, Gem Works, Minerva Rd, London, NW10
GUYSON INDUSTRIAL EQUIPMENT LTD, North Avenue, Otley, Yorks

HACKBRIDGE & HEWITTIC ELECTRIC CO LTD, Hersham, Walton-on-Thames, Surrey
HANCOCK & CO (ENGINEERS) LTD, Progress Way, Croydon, Surrey
HIRST ELECTRONIC LTD, Gatwick Rd, Crawley, Sussex

IGRANIC ELECTRIC CO LTD, Elston Rd, Bedford
ILFORD LTD, Ilford Essex
IMPERIAL CHEMICAL INDUSTRIES LTD, ICI Ho, Millbank, London, SW1

KERRY'S (GREAT BRITAIN) LTD, Warton Rd, London, E15
KODAK LTD (INDUSTRIAL SALES DIV), Kodak Ho, Kingsway, London, WC2

LANCASHIRE DYNAMO ELECTRONIC PRODUCTS LTD, BEP Works, Rugeley, Staffs
LINCOLN ELECTRIC CO LTD, Black Fan Rd, Welwyn Garden City, Herts

MARCONI INSTRUMENTS LTD, Marconi Ho, Strand, London, WC2
MERITUS (BARNET) LTD, 36 Wood St, Barnet, Herts
METAL & PIPELINE ENDURANCE LTD, Artillery Mansions, Victoria St, London, SW1
METALLISING EQUIPMENT CO LTD, Chobham, Surrey
METRO-CUTANIT LTD, Grappenhall, Warrington, Lancs
METROPOLITAN-VICKERS ELECTRICAL CO LTD, Trafford Park, Manchester, 17
MUREX WELDING PROCESSES LTD, Waltham Cross, Herts

NEWMAN INDUSTRIES LTD, Yate, Bristol
NEILL & CO (SHEFFIELD) LTD, JAMES, Napier St, Sheffield, 11
NORTON ABRASIVES LTD, Bridge Road East, Welwyn Garden City, Herts

OXHYCARBON CO LTD, 299 Morland Rd, Croydon, Surrey

PALMER AERO PRODUCTS LTD, Herga Ho, Vincent Sq, London, SW1
PANTAK LTD, 72 Alpha St, Slough, Bucks
PETBOW LTD, Sandwich, Kent
POLLOCK & PEEL LTD, South End, Croydon, Surrey

QUASI-ARC LTD, Bilston, Staffs

REDIWELD-OERLIKON ELECTRODES LTD, 17 Kelvin Way, Crawley, Sussex
ROCKWELD LTD, Commerce Way, Croydon, Surrey
ROSS & PARTNERS LTD, DONALD, Twinner Works, Gatwick Rd, Crawley, Sussex

SAFETY PRODUCTS LTD, Redhill, Surrey
SATURN INDUSTRIAL GASES LTD, Gordon Rd, Southall, Middx
SCIAKY ELECTRIC WELDING MACHINES LTD, Falmouth Rd, Slough, Bucks
SHEFFIELD SMELTING CO LTD, Royds Mill St, Sheffield, 4
SIEBE, GORMAN & CO LTD, Davis Rd, Chessington, Surrey
SOAG MACHINE TOOLS LTD, Juxon St, London, SE11
SUFFOLK IRON FOUNDRY (1920) LTD, Sifbronze Works, Stowmarket, Suffolk

TURRET GRINDING WHEEL CO LTD, Fordbridge Rd, Sunbury, Middx

ULTRASONOSCOPE CO (LONDON) LTD, Sudbourne Rd, London, SW2

VACU-BLAST LTD, 4 Golden Sq, London, W1

WELDING SUPERVISION LTD, Duncan Ho, Dolphin Sq, London, SW1
WELDING SUPPLIES LTD, Beechings Way, Gillingham, Kent

YATES PLANT LTD, Whidborne St, London, WC1
YOUNG & CO LTD, A. S., Tower Works, Woodside Lane, London, N12

'The Windscale accident has focused attention on the storage of energy in graphite, and the lessons learnt will help to ensure the safety of nuclear power development in the future'—Sir John Cockcroft

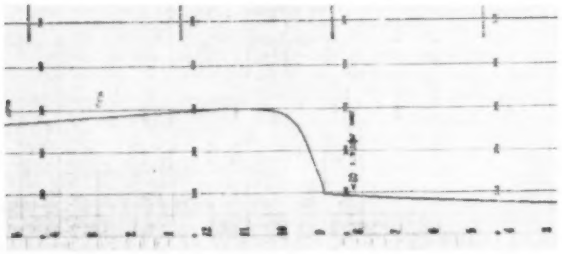
Harwell Wigner release

first since Windscale

A NEW METHOD of releasing stored energy was recently carried out successfully on BEPO at Harwell. Instead of making the reactor critical with no coolant flow the air was preheated, while the reactor was kept running at a very low power level—just sufficient for the operation of the burst slug detection gear to be checked. Experimental conditions were observed and the object was to demonstrate that a Wigner energy release can be performed with complete safety when it is fully instrumented. 'It was a large scale engineering experiment' an Authority spokesman told NUCLEAR POWER, and was designed to give as much help as possible to future designers and control staff.

BEPO is an air-cooled graphite-moderated reactor of the same type as Windscale, and it was during a similar operation there that the temperature of the uranium went too high. The first large pile to be built in Europe, BEPO has been running without trouble for nearly ten years, producing radioisotopes for use in medical research and treatment and in industry. It was shut down in December for a periodic overhaul, and following the advice of the Fleck committee which reported on the Windscale accident, extra instruments were added, including more filters to prevent any escape of radioactive iodine up the chimney.

The release was started by switching on 750 kW of heating grids installed in the air inlet duct and reducing the flow to about 5 pct of normal. The air temperature rose to 130°C thereby slowly heating the graphite structure over a period of ten hours to about 90°C. At this point a slow release of stored energy began as the carbon



The temperature of some graphite blocks rose 200°C in five minutes as the energy release began. The time scale on the chart reads from right to left

atoms returned to vacant lattice positions from which they had been knocked out by bombardment of fast neutrons in the five years since the last Wigner energy release on BEPO. The temperature of the graphite rose, in some places by as much as 200°C in five minutes, and the thermal wave spread slowly from the air inlet end of the reactor along the fuel channels to the exit end and radially out from the channels. The maximum temperature reached in the graphite was 330°C. About 26 hours after the beginning of the operation the temperature was falling steadily in all parts and the release was considered to be at an end.

AFTER WINDSCALE

It was during a Wigner energy release that the Windscale accident occurred and the AEA now reveals that about three tons of uranium was oxidized. Tests made by the London County Council showed that in terms of previous experience there was an unusually large amount of fission products in the air over London during the 24 hour period ending at noon on October 12, the amount on the previous day being negligible. At a recent meeting of the Royal Society of Health the Senior Principal Scientific Officer of the LCC stated that activity was easily observed using material filtered from one cubic metre instead of the usual 100-1000, and it was possible to make quantitative measurements on filter papers used for the routine determination of smoke in the atmosphere. With the cooperation of some twenty-five medical officers of health throughout the country a large number of filter papers were collected and compared under the same conditions. The results gave a consistent picture showing that the cloud of airborne matter had moved in a south-easterly direction from Windscale at a rate of about 200 miles in a day. The total amount of radioactive matter inhaled by a person in London during the period of exposure was estimated to be of the order of 0·01 microcurie, expressed as beta activity.

The whole operation was controlled by a battery of 7[illegible] recorders, and a total of 411 iron-constantan and cromal-alumal thermocouples was used, including 232 at different points in the graphite, while 65 recorded the uranium fuel element temperatures. In charge of the 75 engineers and scientists engaged in the recording was Mr R. F. Jackson, head of the reactor engineering operations group. He was advised by Dr A. H. Cottrell (metallurgy) Mr J. H. W. Simmonds (graphite) and Dr D. W. Fry (physics). Sir John Cockcroft and Dr B. F. J. Schonland were present. The reactor could at any time have been blown cold by turning on the main circulating fans. 'We have confirmed therefore' say the Authority, 'that a Wigner energy release can be carried out with complete safety when it is fully instrumented.'

New radiography unit

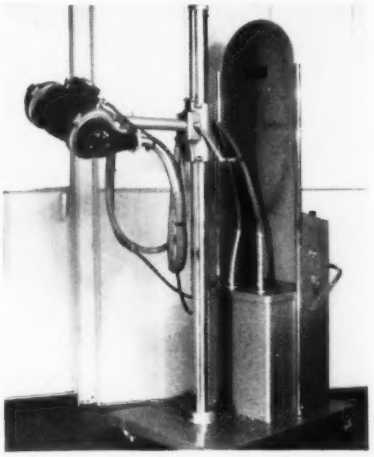
Marconi Instruments Ltd have announced an addition to their comprehensive industrial X-ray range. The new equipment, type TF 1597, is an 110 kVp apparatus, designed for 200-250 volts a.c. operation, and basically consists of three units—h.t. generator, control unit and tubehead. The method of mounting these units depends upon individual requirements, and the company's X-ray engineers are prepared to advise and design a suitable arrangement to meet any particular inspection problem. Each of the basic units is portable, which makes the apparatus suitable for a wide range of applications in the field of nondestructive testing.

The 110 kVp h.t. generator is oil-immersed in a welded-steel tank. It comprises the h.t. transformer and an X-ray tube filament transformer. Two 62·5 kVp cable sockets provide the output to the X-ray tube, while the input from the control unit is taken to terminals at one end of the tank.

When supplied as a portable unit, the h.t. generator is fitted with a pair of carrying handles. These handles are conveniently placed so that the control unit can be rested across the top of the tank when in use, or for storage.

The control unit is housed in a rectangular case with a sloping panel on which are mounted all controls and meters. A stout leather carrying handle is provided to facilitate portability. The hinged top and front panel of the unit may be swung down to gain access to the components and also to the fuses. A synchronous motor-operated self-resetting timer is incorporated, and the customer can make his individual choice from a wide selection of ranges.

The X-ray insert tube normally supplied can be operated up to 110 kVp, 10 mA, and provision is made for water cooling at the higher ratings, circulation being derived from the normal tap supply. Standard tubehead mountings at present available are:—1. A static tubestand, fitted with four telescopic legs and providing facilities for angulating the tubehead about its short axis. 2. A vertical column tubestand, mounted on a castored base, which is large enough to contain the h.t. generator and the control unit; the latter is removable for remote operation, if required. 3. A fluoroscopic cabinet, which houses the complete equipment and has a specially constructed control panel built in. Facilities are also provided for radiography with this arrangement.



The three basic units can be mounted to suit individual requirements

Tick **No 135** on reply card

Easy inspection of radiographs

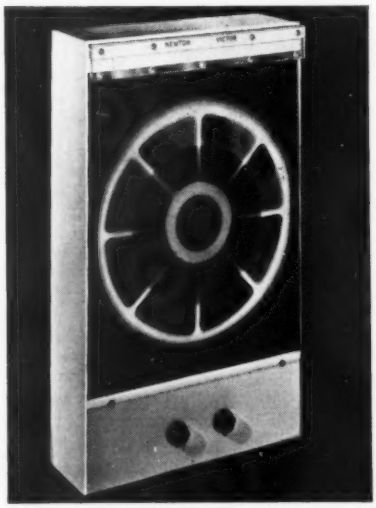
Maxilume illuminators for examining radiographs up to 14 in. by 17 in. have recently been introduced by Newton Victor Ltd, X-ray department of Metropolitan-Vickers. The new design incorporates many improvements ensuring greater accuracy and convenience for the critical examination of X-ray negatives.

A feature of the illuminators is the use of 15-watt colour-matching fluorescent lamps giving an evenly diffused, glareless light of true north daylight character with a complete absence of flicker. These are fitted in an efficient reflector with a special plastic diffuser panel of high light transmission characteristics.

The film to be examined is held in position by means of a ball type film holder mounted in a clear Perspex bar which enables the very top edge of the film to be seen. This important feature of the new design ensures easy trouble-free insertion, and firm retention of the negative without scratching or marking.

When heavier densities up to 2·5 are to be examined, the illuminator can be fitted internally with a high-intensity photoflood lamp so arranged that the fluorescent tubes are switched off when the photoflood lamp is used.

A dimming device can also be supplied, in which case an extra control switch is provided on the front panel as shown in the illustration. The dimming device provides a means of regulating light intensity from full down to 15 pct of maximum. The rotary control of the



The illuminator normally uses fluorescent tubes but a high-intensity photoflood is also fitted

front of the illuminator, next to the on/off mains switch, reduces intensity to 75 pct and 60 pct in two steps and then continuously to 15 pct. The illumination from the viewing panel remains uniform with complete absence of irritating flicker and 'instant starting' is possible at the reduced intensities.

Illuminators and accessories are available from stock. The standard unit is £13 and with a dimming device, £15 15s.

Tick **No 136** on reply card

Pipe weld inserts

Already used in the United States in the construction of nuclear-powered submarines, the EB Weld Insert process is now available in this country through Rockweld Ltd. It is used for pipe joints where a root run weld must be of the highest quality.

The EB Weld Insert is a wire of special section which is fitted between the prepared ends of the pipes to be joined, and subsequently fused to provide a root weld of high quality, and smooth contour both internally and externally. The insert is available in two sizes, nominal ⅜ in. and nominal $\frac{3}{16}$ in. the latter being the more common size and the ¼ in. being used only for thin walled pipes. It is available in three qualities of stainless steel, three qualities of low alloy steel, and in mild steel, in length multiples of 25 feet.

The insert is tack welded to both pipe preparations using an argon-arc torch. By means of suitable blanking disks the sections of pipe adjacent to the joint are

blanked off and a supply of argon fed into this section continuously. The inserts and pipe preparations are then fused by means of an argon arc torch and the capilliary forces are such that

(Above) the insert is first tack welded then (below) it is fused to the edge preparation

the internal surface contour is smooth, uniform and free from objectionable resistance to fluid flow. The surface contour is almost independent of whether the weld is taking place in an overhead, horizontal or vertical position.

Because of the careful pipe preparation required and the necessity for an internal argon atmosphere, the EB Weld insert process can only be justified in special applications where the very highest quality of join must be obtained without the use of conventional backing rings.

Tick **No 137** on reply card

Improved electrodes

To improve the quality of welds made by their *Argonarc* process, British Oxygen Gases Ltd have now introduced two new types of tungsten electrodes. Under good welding conditions, a tungsten electrode is virtually non-consumable, provided it is chemically pure, but impurities can bring about a reduction in its melting point and also in its operating life. The addition of small percentages of thorium or zirconium, however, improve emissivity.

One of the new electrodes contains a total of 2 pct thorium, and the other contains 1 pct zirconium. Striking the arc with the 2 pct thorium electrode is claimed to be easier than using the previous thorium electrode which contains only 1 pct.

The zirconiated electrode is claimed to be of particular value where tungsten contamination of the weld cannot be tolerated.

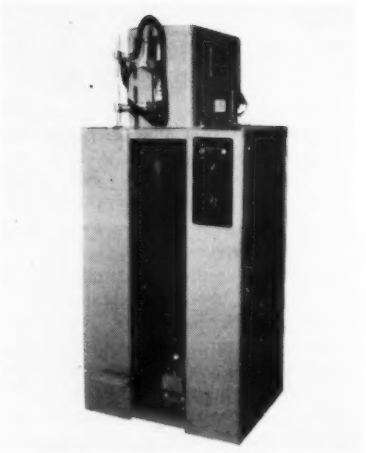
Tick **No 138** on reply card

Spot welding machine

The popular range of Meritus *Autoforge* bench-type spot welders has, for a number of years, been providing a valuable service to manufacturers of sheet metal and wire goods assemblies. The speed of operation in conjunction with the electronic weld time control making them very suitable for this class of work.

Recently, however, there has arisen a demand for a machine for use on Air Ministry and other Government contracts, particularly with reference to the nuclear energy programme, which specify that the spot welding machines used must have completely automatic control of both welding time and 'hold down' or forging time.

To meet this demand a range of Meritus bench-type spot welding machines, 5 kVA, 6 kVA and 8 kVA has been designed, fitted with the Meritus patented *Autoforge* interlocking mechanism, which has hitherto been available only on the larger Meritus pedestal-type spot welders. The Meritus *Autoforge* system ensures that the control of the welding machine is completely automatic in all respects



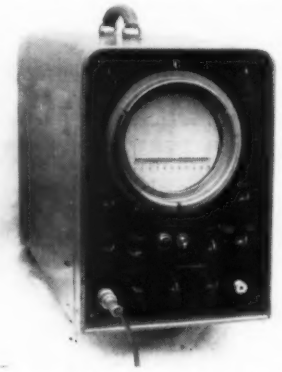
Both welding time and hold down time are automatically controlled

making it impossible for the operator to 'beat the timer' and also giving close and accurate control of the forging period. This machine will be exhibited at the Brussels World Exhibition 1958.

Tick **No 139** on reply card

Ultrasonic test equipment

Until recently no effective method of non-destructively testing lead was available apart from the illustrated use of very high power X-rays. The latest *Ultrasonoscope*, however, has been found particularly suitable for testing lead shielding for discontinuities which might affect its absorption characteristics.



One use of the apparatus is the testing of shielding lead for cavities

Thicknesses up to 20 in. have been tested, defects $\frac{1}{4}$ in. o.d. located at 10 in. depth and defects as small as $\frac{1}{32}$ in. or less at 2 in. depth. The equipment is portable, simple to use and no great skill is required by the operator.

The very versatile *Ultrasonoscope* designed and made in England is also used on several other nuclear applications, notably graphite quality control, heavy section weld testing, heat exchanger weld testing and checking steel plate for lamination.

Tick **No 140** on reply card

Inspecting condenser and heat exchanger tubes

The Sperry *Introview* has been designed specifically for the nondestructive testing of metal tubes of low magnetic permeability installed in condensers and heat exchangers. The instrument facilitates the routine examination of these tubes and permits an accurate assessment of their condition. This enables the maximum life to be obtained and arrangements for replacement to be planned in advance of failure. Under aggressive conditions of service this makes for improved economy of operation.

Manufactured under licence from Imperial Chemical Industries Ltd, the instrument consists of a probe and recording unit. A power pack and a small electrically operated cable winch are provided as auxiliary equipment. Speed of testing has been given particular consideration, and the *Introview* is normally supplied to operate with a probe speed through the tube of 120 ft per minute.

The recording unit produces on a moving chart a record of the local condition of the material under test, chart and winch speeds being interrelated.

The traces on the chart record the

electrical characteristics of the coils in the probe. These characteristics are upset—and the trace records a change—when the coils are in proximity to portions of the tube wall which differ in physical or electrical characteristics from neighbouring portions.

A comprehensive range of probe sizes can be provided. Experience in interpreting the traces is necessary, but once this skill has been acquired by the operator the *Introview* may be counted on to give a reliable guide to the condition of a tube and to indicate when it would be advisable to replace it.

Tick **No 141** on reply card

Much in little

An interesting miniature welding set with a maximum welding current of 160 amps has recently been introduced by Balbo Welding Processes Ltd. The Balbo *Midget* will successfully operate on a supply input of only 20 amp at 230 volts, and provide an easily struck, smooth running arc with full penetration.

The machine is designed for a wide range of work and will enable the user to produce sound strong welds in downhand, vertical or overhead positions for any type of joint. It is particularly suitable for constructional work on site, yet it can be used for industrial repetition work on metals ranging from 20 gauge sheet to one inch plate.

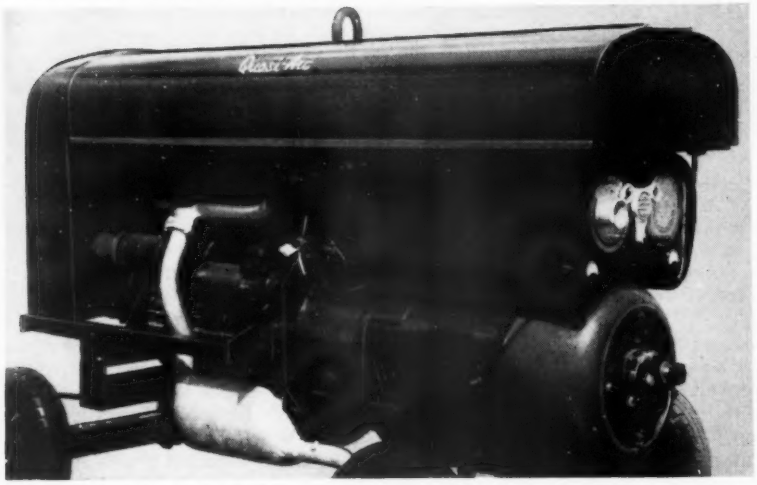
Here is the specification of the Balbo *Midget*: *transformer*, Double-wound, air-cooled. Baked in best quality impreg-

The set is sold complete with all accessories

nating varnish; *mains input*, 190/500 a.c. 40/60 cycles; *primary current*, 190/250V 5/25 amp, 380/500V 4/13 amp, for operation on any two phases of a 3 phase supply — alternatively between I phase and neutral or on single phase; *rating*, maximum welding current 160 amp, minimum welding current 20 amp, continuous hand welding current 120 amp, kVA at BS rating 4·6, continuous kVA rating 3·2; *capacity control*, 8 swg to 16 swg electrodes inclusive, fifteen variations in output current between 20 and 150 amp, designed to cover all requirements for each gauge of electrode; *dimensions*, 15 × 12 × 11½ in.; *weight*, 98 lb.

Tick **No 143** on reply card

For welding on remote sites



A calibrated knob and dial on a common spindle provide continuously variable control of open circuit voltage over the whole range of 50-95 volts

A new diesel engine-driven arc welding set has been added to their range by Quasi-Arc Ltd. Known as Type DEB.400U, it is of robust construction, but its light weight and relatively small size permit easy manœuvrability. The set has quick voltage recovery and is particularly suitable for depositing the cellulose-covered types of electrode frequently used in positional pipe welding, which are covered by the AWS/ASTM classification E6010 or the BS classification E.110.

The set has a particular application for work on remote sites where mains electricity is not available. It gives stable arc conditions when used for pipe welding with Quasi-Arc *Celtian* electrode, and with all other ferrous and non-ferrous types.

The principal details of the equipment are as follows: *max current*, 400 amp; *max continuous hand welding current, (to B.S.* 638:1954) 300 amp; *continuous test current (to B.S.* 638:1954), 210 amp; *min open circuit voltage*, 50; *max open circuit voltage*, 95; *weight without undergear*, 19 cwt; *dimensions without undergear*, 50 × 27 × 50 in. high; *NEMA rating*, 300 amp d.c. at 40 arc volts, 60 pct duty cycle.

The generator is flange-coupled to a Ford four-cylinder water-cooled industrial diesel engine, with electric starting and a heavy flywheel to ensure satisfactory emergency hand-starting. A feature of the new set is the fully automatic idling device. Pneumatically operated, it is arranged to reduce the engine to idling speed automatically when welding is not in progress. No switch or other control is necessary on the electrode holder since the flow of welding current controls the device directly. A pre-set adjustable time delay prevents the engine idling during pauses in welding, such as would be encountered when electrodes are changed. The engine rapidly reaches full speed upon the commencement of welding following a period of idling. This device is capable of giving worthwhile reductions in fuel consumption, especially during site welding under difficult conditions, where frequent interruptions of the arc are necessary.

Tick **No 142** on reply card

In brief

Automatic scanning of paper radiochromatograms is accomplished by the new *Actigraph II* by Nuclear-Chicago Corporation. It scans, counts and records automatically the radioactivity distribution.

Tick **No 144** on reply card

New **light-actuated switch** using a phototransistor is announced by Photoelectronics (M.O.M.) Ltd. It can be used in any application where a light beam is broken or varied.

Tick **No 145** on reply card

Low-priced 62 curie **cobalt-60 irradiation unit** is marketed by Radiation Applications Inc. Called the *Gammalab*, it can give a dose rate of over 100,000 r/h yet stands less than 2 ft high.

Tick **No 146** on reply card

Isotope Developments Ltd. It is regretted that the *GammaSwitch* made by this company was inadvertently attributed to Infra Red Developments Ltd in a caption to its picture in last month's preview of the IEA exhibition.

Spanning the working area the crane can move back to the welding site where one pressure vessel section is being completed under cover. Preliminary welding of the sections is carried out in the sheds, and each section is then assembled on one of the eight star-shaped concrete rests with the help of a smaller Goliath. In a recent test the big crane lifted 200 tons of concrete

Goliath crane in action at Bradwell

now completed, it will save up to six months on site

THE GOLIATH CRANE is now in service on the site of the Bradwell nuclear power station and will soon move the first pressure vessel section from the fabricating area to No 1 reactor. The 800-ton crane, believed to be the largest of its type in the world, was built so that it could move the very heavy boiler and reactor structures while allowing civil engineering work on the reactor buildings to go on without being hindered by their installation. It took fourteen months to build, but its use should reduce the time taken to construct the station by up to six months. It is hoped to run No 1 reactor up to power in June 1960. He added that although design was for a 200 ton maximum load 278 tons was handled on its acceptance trials. The first of the six 200 ton boiler shells will be floated down the North Sea in the next few weeks from the Thornaby-on-Tees factory of Head Wrightson to Bradwell, where the Goliath will hoist it horizontally and lower it on to its vertical mountings at the end of a reactor.

Controlled essentially by one man, the crane is 177 ft high—as tall as Nelson's column—and completely straddles the reactor site. Each end is mounted on eight four-wheel bogies running on standard gauge railway lines built on piled tracks 178 ft apart, so that the crane can move 1200 ft from the boiler reception centre back to the welding site behind the reactors where the ring segments of the pressure vessels are being fabricated with the help of a 40-ton Goliath crane.

Some vibration troubles

NUCLEAR POWER went to Bradwell to see it in operation recently and watched it lift two 100-ton blocks of concrete and move them about the site—the heaviest load lifted by a Goliath type crane in this country. It carries its own power unit—a 400 bhp Crossley diesel engine direct coupled to a Clarke Chapman 200 kW generator giving current at 460 volt d.c. for all the crane motions—thereby avoiding trailing cables and making it independent of any local power supply failure. A separate engine-driven set provides compressed air for starting the main engine and supplies air at 250 psi to an air receiver on the wall of the engine room, which is a self-contained unit with built on fuel and water tanks and is mounted in one of the legs of the crane some distance above track level. Some vibration troubles have been experienced and it may be later mounted on a separate bogie, our reporter was told.

Wind loads the worst

The crab is of conventional design and has two independent hoists running on rails on a pair of girders, each one being provided with its own horizontal outrigger girder to give lateral stiffness. The main girders are supported at each end by legs of similar construction and the main vertical loads are taken through pin-joints. At its base each leg is pin-jointed to equalizer beams which in turn spread the load to two other equalizers connected to the bogies through universal connexions. By this arrangement the load is equally distributed over all the axles in any one leg.

The crane is designed for a maximum horizontal wind load of 5 lb per sq ft under the worst working conditions and Mr. J. Baker, General Manager of Clyde Crane & Booth Ltd, told a NUCLEAR POWER reporter that designing for wind loads was one of their most difficult problems. 'We couldn't, of course, decide what to allow for the wind until the main projected area was known' he said. 'In the end, because of the wide spacing we proceeded on a basis of allowing twice the projected area instead of the normal one and a half times for lattice structures.'

The wheels and axles of the bogies are of standard railway pattern running in phosphor bronze bushed bearings and the front and rear axle in each bogie are driven through worm and spur gearing by a 20 hp motor. Coup-

ling rods transmit the drive from each geared axle to the matching axle on the same outer bogie so that the crane is moved by 32 driven wheels. The eight 20 hp motors can move the crane at 50 ft per min when carrying a 200 ton load. Eight solenoid brakes are fitted to the travelling motion to hold the crane when at rest, normal braking being obtained by plugging through the control gear. In the event of gales the crane can be further anchored by storm clamps.

To guard against 'skewing' of the legs due to their independent operation on each track an indicator synchronized by a BTH *Selsyn* control is provided in the cab so that the driver can see to what extent bogies at opposite ends of the tracks are being maintained in line. If necessary one end of the crane can be driven separately to bring the two ends into line but so far, we are informed, skewing has never exceeded an inch or two.

Walkie-talkie sets used

All the crane controls are located in a cage which is suspended from an extension on one side of the crab and hangs below the top girder assembly. This position gives the driver a clear view of the load, which is always directly below and in front of him, and the whole of the working area. Each motion is capable of independent operation by means of a master reversing controller which operates magnetic contactor gear.

Because of the size and length of travel of the crane and the fact that other work will be proceeding while it is in operation some thought had to be given to the necessity of making sure the rails in front of the bogies were kept clear, Mr Baker told NUCLEAR POWER. The use of telephones mounted on each bogie was at first considered but it was decided that the men detailed to walk beside the bogies would communicate with the cab by means of 'walkie-talkie' sets.

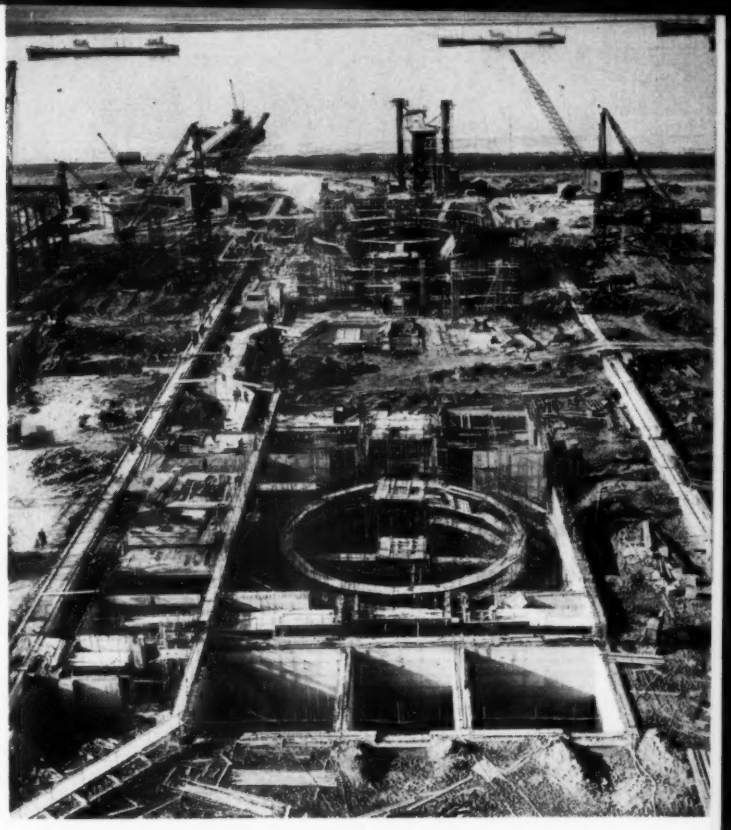
The hoisting equipment consists of standard crane spur gearing housed in totally enclosed steel gearboxes, the shafts running on ball and roller bearings. Barrels of steel tube construction are machine grooved and arranged to coil the rope without overlapping. Overwinding and overlowering switches are provided for both main and auxiliary hoists which are each powered by two 50 hp motors to give a lift of 200 tons at 4 ft 9 in. per min and 30 tons at 33 ft per min respectively. The speed of lowering on each hoist is governed by potentiometer dynamic braking and the rating of the resistances is such that the full load can be lowered the whole length of travel of the hook once an hour. Automatic solenoid brakes are fitted to each hoist. When raising the maximum load of 200 tons the deflexion of the crab girders is of the order of $\frac{3}{4}$ in. at the centre.

The crab can be traversed across the working area at 50 ft per min by two 20 hp motors when carrying a 200 ton load. When the current is off it is held in position by two solenoid brakes, and during normal operation braking is obtained by plugging through the controllers.

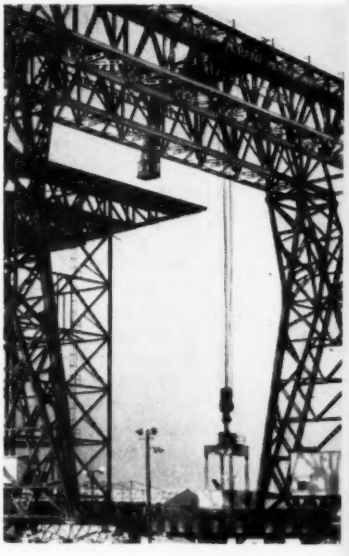
Another Goliath ordered

The crane was erected on site using a large steel working platform and a jib crane. The working platform was used to hold the crab supporting girders while work on the legs proceeded and is now being dismantled, but the jib crane will remain in service as it runs on rails at right angles to the Goliath travel and can be moved clear when necessary. Shop-riveted sections were transported to the site and bolted there, 40,000 bolts being used. This method of construction was used as the crane will be dismantled when the power station is completed. This will take 3-5 months, according to Mr. A. Young, NPPC's resident site engineer, and it is hoped to erect and use it again for a future nuclear power station.

Clarke Chapman & Co Ltd is the member company of the NPPC responsible for the handling of heavy lifts at Bradwell and in order to meet these requirements they placed the contract for the Goliath crane with their associate company, Clyde Crane & Booth Ltd. Subcontractors for the steelwork were the Tees Side Bridge and Engineering Works Ltd. Rendell Palmers & Frew Ltd checked the stress calculations. Another and larger Goliath crane—of 250 ton capacity—has been ordered by the contractors with an eye to future nuclear power stations, and will be ready in about two years.



From his cab the driver has an uninterrupted view of the reactor sites. No 1, nearest the river, is furthest advanced and the crane, moving down to the end of its rails, will pick up the first boiler when it is floated down to Bradwell in May. Cladding of the turbine house, just visible on the left, will be carried out in June



When the crane working platform is demolished in a week or two the base of the No 1 pressure vessel in the foreground will be lifted into position

In the new beryllium research laboratory, handling operations are done in ventilated working boxes. In the foreground is a batch-sampler for beryllium monitoring

Developed at GEC, this power manipulator can lift 750 lb on hook, is the equivalent of a human arm and hand

Towards improved reactors

GEC expands nuclear research facilities

WHEN IT WAS ORIGINALLY equipped, the main objective of the General Electric Co's Atomic Energy Division at Erith was to produce, very quickly, a complete design for the first round nuclear stations. Since then there has been considerable expansion, with new laboratories and equipment designed to improve the original design—to increase efficiency and reduce costs and to adapt it for special needs, especially the overseas market.

Outstanding in these developments is a new laboratory for beryllium research. The advantages of this metal for high temperature reactors—especially as fuel cans—are well known and, over eight years' experience of beryllium working, the AEA have developed safety methods for handling this highly toxic material. Designed to study the chemical and physical properties of beryllium in fabricated form, this laboratory has been specially planned to meet these high safety standards. Most important of these is the achievement of a working atmosphere where the average atmospheric concentration of beryllium does not exceed 2×10^{-6} g/cu m throughout the working day.

Working with beryllium

The laboratory is a two-storey brick building with concrete roof. Normal entry is through a change room where personal clothing is left on one side of a dividing barrier and laboratory clothing, including head and footgear, is provided on the other. Here there are washing facilities, a shower, a washing machine with a spin drier and a drying cabinet—all laundry is done on the spot.

The working area is divided into two parts, separated by a sliding door. One is designed for operations of greater potential hazard and has an air-extraction rate double that of the other. In area A there is one complete air change every 23 minutes, with one every 45 minutes in area B. The air-conditioning system, designed by J. Jeffreys & Co, comprises one central inlet duct and two ranges of extract ducting running along the laboratory walls at ceiling height. A fan with capacity of 6000 cu ft/min draws air in through a bank of filters followed by a steam-to-air heat exchanger thermostatically controlled to maintain an inlet-air temperature of 75°F. The more complex extract system consists basically of a fan drawing air out at the rate of 8000 cu ft/min through twelve Vokes absolute filters. These are arranged in two banks of six, coupled in parallel to the extract fan. Each filter is individually mounted in a cell in the manifold to minimize hazard during changing. They have a guaranteed efficiency of 99·5 pct removal of particles in the 0·1 to 0·5 micron diameter range. Efficiency is virtually 100 pct for particles over 1 micron. Extract is drawn from the laboratory through working boxes and hoods, coupled to the main ducts.

All experiments involving beryllium handling will initially be carried out in ventilated working boxes, each designed round a specific operation. Those involving the formation of beryllium dust or chip—machining, abrasion and welding for instance—are confined to laboratory A where the highest ventilation rate is available. Working boxes are of two types: for high temperature experiments, they are made of sheet metal on an angle-iron frame, and for general laboratory techniques a Perspex hood is attached to a conventional bench, in which access is through a Perspex working face incorporating a hinged

door and a series of sliding doors. For welding work a glove box is used. New operations are initially performed in fully protective clothing with an external air line.

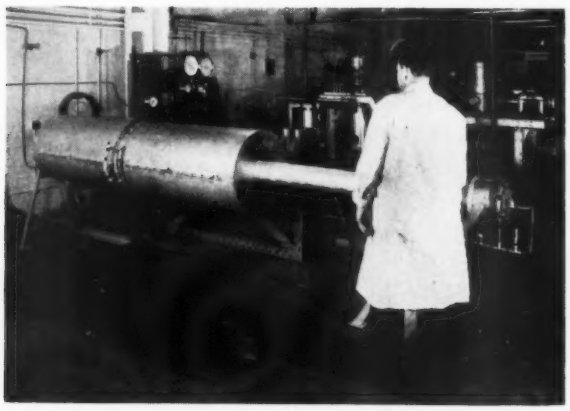
In laboratory B work is mainly centred on the properties of beryllium at high temperatures. Oxidization properties at 600-650°C and higher are studied in a CO_2 atmosphere with small traces of CO and water vapour added to simulate reactor conditions. Stress rupture in a pure argon atmosphere and corrosion in carbon dioxide are also studied.

Beryllium monitoring is difficult and at present spectrochemical techniques on a batch sampling basis provides the best safeguard. In collaboration with the GEC research laboratories at Wembley, a sampling and analytical scheme is used taking air samples of about 10 cu m ; as little as $0{\cdot}015 \times 10^{-6}$ g can be detected. In addition to monitoring specific operations, routine background samples are taken daily over a period of eight hours.

British power manipulator

Designed at Erith, this new remote-handling tool can lift and accurately position 750 lb on hoist and has a grip of up to 150 lb. It comprises one grasping jaw carried on a continuous rotation wrist, supported from a forearm, upper arm and shoulder. Each arm joint can rotate through 180° about its pivot and the shoulder rotates continuously about a vertical axis. The crane-type carriage can be traversed across a gantry spanning the working area and travelling on longitudinal rails mounted near the top of the cell walls. The gantry also supports a 1½ ton electric hoist with a cross-traverse parallel to that of the manipulator carriage. The body within the carriage is telescopic with positive raise and lower action. Particular care has been taken in the selection of materials to ensure long life under gamma radiation: organic insulating materials have therefore been avoided.

All motions are powered by vf 3-phase, squirrel-cage induction motors, selected for their rugged construction,

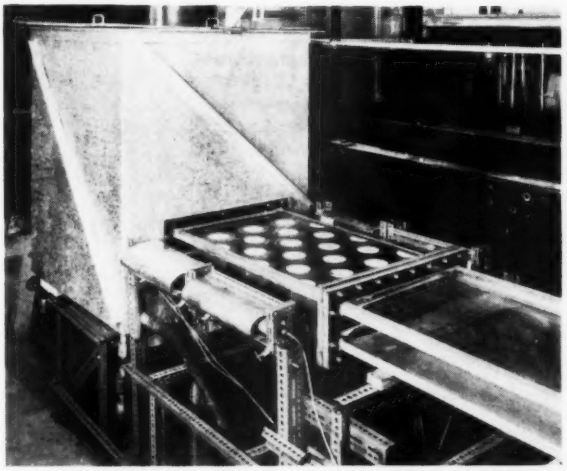


The effect of thermal shock due to charging on the structure of fuel elements is investigated in this test rig, comprising a 14 ft cylindrical channel, heated at one end

compact size, freedom from brushgear and the fact that no insulating material is required in the small rotors. To ensure that there is no movement in the event of a power failure all motors are fitted with brakes.

Control is by two joystick-type handles with simultaneous movement in four directions, arranged to follow logically the movement of the manipulator. Degree of displacement of the joysticks is proportional to the speed of the corresponding manipulator movement. Jaw grip is indicated on non-linear scale marked from 0-150 lb with 15 lb as the midscale value for sensitivity in handling light objects. Further indication is given by an audible signal.

Among the new equipment installed in the heat laboratory is an apparatus for investigating the heat transfer characteristics of various fuel can designs. As in the early stages of this work, the main measurements are made in a carbon dioxide atmosphere at reactor temperature and pressure. Heat is supplied to the can by a close-fitting



A water model is used to investigate flow round heat exchanger tubing, using polystyrene particles as markers. White disks in the horizontal channel are the tops of vertically mounted Perspex models of the tubes

tubular element and the complete unit inserted into a lagged tube. In addition there are now two rigs using air, one operating on forced and the other on induced draught. These give a quick assessment of performance.

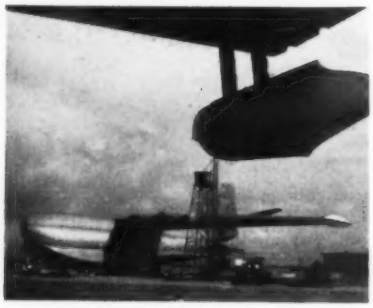
A second wind tunnel has been installed for experiments on heat transfer characteristics of heat exchanger tubing. As in the original tunnel, dry superheated steam is passed through the tubes and the condensation caused by an air-stream measured; in this new tunnel, a greater range of air mass flow is obtainable. Flow patterns in water are also used for performance studies on finned tubes. For fuel elements, the water flows longitudinally over a full-scale can mounted in a transparent cylindrical channel and a marker dye or suspension injected into it. For work on heat exchanger tubes, the apparatus comprises a horizontal rectangular Perspex channel in which Perspex models of the tubes are mounted vertically. Small particles of polystyrene are used as markers.

In the mechanical engineering section there is a 1/20 scale model of Hunterston for investigating coolant flow (picture *Worldview*, April). A 42-in. diameter Perspex sphere with a supporting skirt and rings of inlet and outlet ports houses a duralumin core on an egg-box type support grid. Fuel and control rod channels are represented by tubes presenting proportionally the same resistance to gas flow as the full-scale structure. Air is drawn through the model by a motor-driven blower, and flow and pressure drop measurements made at inlet and outlet ports along selected channels. Thus the effect of shutting down a blower and of channel gags can be investigated.

During charging, a fuel element undergoes a considerable and abrupt thermal shock. To find out its effect on the structure of the element, a test rig has been built comprising a horizontal cylindrical channel, 14 ft long and 6 in. bore filled with CO_2 to 150 psig. One end is heated by two 5 kW electrical elements and the element wound into the hot zone by a chain driven hand wheel.

Flying boats to be nuclear?

The three *Princess* flying boats now laid up at the Saunders-Roe works on the Isle of Wight may be fitted with nuclear reactors. The managing director of the company, Captain E. D. Clarke, and his chief designer, Mr M. J. Brennan went to Washington recently, following discussion of the project by letter. The US Navy is evaluating several types of plane as possible flying test beds for American nuclear aero-engine development and has



Built at a cost of about £M8 the three largest flying boats in the world are now 'cocooned' at Cowes

not yet made a final decision. However Saunders-Roe have been asked to do a feasibility study at American expense. The *Princess* flying boats would certainly be large enough—they are designed for a pay load of 52,000 lb each and are the biggest flying boats in the world—and the use of a seaplane might be desirable for safety reasons.

The three flying boats, built by Saunders-Roe Ltd for the Ministry of Supply at a cost of about £M8, have an unfortunate history. They were originally intended to be powered by ten Bristol Proteus engines and used for a BOAC London to New York passenger service. Ten experimental versions of the engine were fitted to the first *Princess* and it flew for about 100 hours, but the MoS then decided not to go on with the development of the engines for this use. Various other engines were considered but none seemed suitable or powerful enough and the three aircraft were sprayed with several layers of weather resistant coating and laid up in 1954.

APC make reactor agreement

Reactor pressure vessels for nuclear power stations to be supplied by Atomic Power Constructions Ltd will be designed, manufactured and erected by Babcock & Wilcox, it has been announced. In addition Babcock & Wilcox will supply any special heavy duty crane required by APC for the erection of pressure vessels, heat exchangers and other parts of the gas circuits.

Further news of APC's organization was given in the spring number of *The Link*, works magazine of The Richardsons Westgarth Group. Main design and development programme for reactors is being carried out at Heston, where APC has its own laboratories working in collaboration with the Weapons Division of the Fairey Aviation Company. A long range programme of investigation is being carried out on heat transfer problems, compatibility tests, thermal cycling and structural tests. Methods of temperature measurement within reactors are being developed, and work is in progress on beryllium, zirconium, niobium, stainless steel, ceramic fuel, and heat flow from extended surfaces. Mass transfer of graphite and corrosion problems are also dealt with.

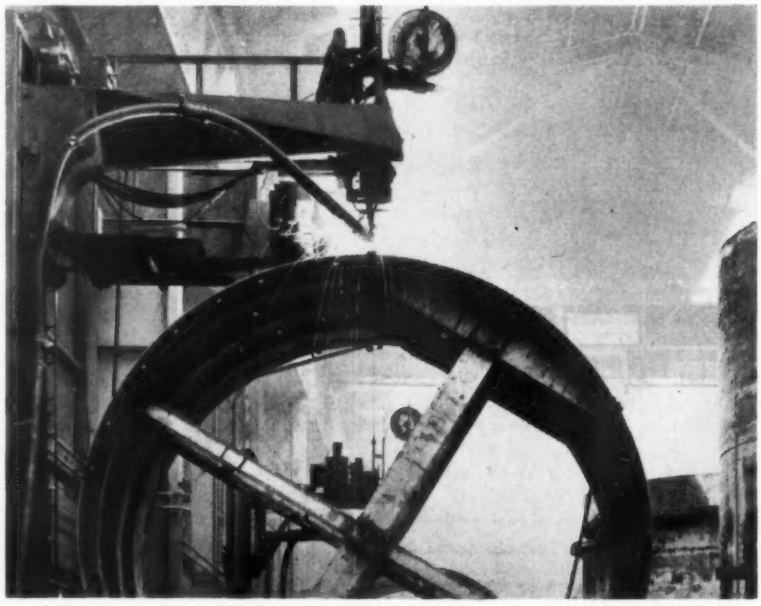
93-ton vessel welded

A nitric acid absorption tower which is now in service at the Wilton works of ICI Ltd is said to be one of the largest stainless steel vessels ever welded. Weighing 93 tons, it is 139ft long and 15ft in diameter, the thickness varying from $\frac{3}{8}$ to $\frac{5}{8}$in. *Fusarc* automatic machines were used for welding, and in order to make the best use of the welding boom for automatically welding the internal seams fabrication was carried out in a series of sub-assemblies approximately 15ft long. Since the usual spiders were ruled out by the use of an internal boom, external stiffening rings were used to maintain concentricity while the welding was in progress. Each circumferential tier was made of three plates and when complete they and the hemispherical ends were welded manually.

For the external welding a universal type of cantilever was employed and beneath this the vessel was mounted on a heavy series roller bed. The internal longitudinal and circumferential seams were welded by an automatic welding head incorporated in a slender boom at the end of which was a cradle in which the operator lay prone. In front of him was a panel which gave him complete control of the welding and when necessary of the speed since he was able to rotate or traverse the roller bed by push-buttons. The welding nozzle protruded below the cradle and the operator could observe the arc through a dark glass screen let into the base of the trough.

Difficult to move The problem of transport from Ashmore, Benson, Pease & Co's works to the Wilton site was solved by manufacturing a specially cranked drawbar weighing a ton and giving only 9in. clearance from the road. The cylinder was carried on several 10-ton bolster bogies. The 18-mile journey took two and a half days and three 50 h.p. Scammell lorries were needed at one point to get it up a hill.

Sections of the 15 ft diameter 139 ft long cylinder were mounted on a heavy series roller bed and welded by a universal type of cantilever



Zirconium study results

Results of the study on the economics of zirconium versus stainless steel as a canning and structural material in nuclear power reactors (*Companies* last month) have now been released by the US Columbia-National Corporation. It was made for the company by Dr Manson Benedict, head of the Nuclear Enginering Department of the Massachusetts Institute of Technology and included a detailed survey of five US reactors.

Main conclusions of the report are that Zircaloy should be used for permanent parts of commercial power-producing reactors fuelled with uranium enriched up to at least 4 pct U-235. For greater enrichment its better neutron economy is less important. Fuel elements should be canned in Zircaloy where natural uranium is used, and for slightly enriched fuel Zircaloy at prices of from $40-$60 a lb appears to be competitive with stainless steel at $5 a lb where the volumes are about the same. A study of the effect of power factors indicates that Zircaloy can be seriously considered for fuel element cans, as well as permanent parts, in reactors which are likely to be operated at load factors below 80 pct, such as those used for marine propulsion. It was also found that for a given power level Zircaloy becomes more attractive as the fuel lifetime is increased.

Complete agreement with the report was expressed by Dr W. K. Lewis, Vice-President for research and development of Atomic Energy of Canada, but he added, 'Even the neutron absorption of Zircaloy is of concern to us, and we have to consider how thin we can make both the fuel cladding and the pressure tubes we are now proposing for our power reactor. We are therefore more ready to pay a good price for Zircaloy if it meets a high metallurgical and corrosion-resistance specification and tight dimensional tolerance.'

Zirconium prices will fall Commenting on the overall results of the investigation Mr. Gordon Kiddoo, Vice-President and General Manager of Columbia-National said 'It is evident to us that there is a very definite place for zirconium in the power reactor field. The extent of its use will depend in large part on which reactor designs prove most economical and in the availability of zirconium fabrications at lower prices.' The company has polled the leading mill-products manufacturers and concludes that the price of zirconium tubing can be expected to fall.

Tailpiece The company has announced shipment of its first lot of reactor-grade zirconium sponge to the USAEC. 3,500,000 lb are to be shipped in the next five years. According to a company spokesman much of the metal will be used in the construction of reactors for the US navy's atomic powered fleet.

After discussing the economics of UK type reactors Dr Gunnar Lindstrom and members of Swedish electricity undertakings went round Berkeley

Swedes talk with nuclear groups

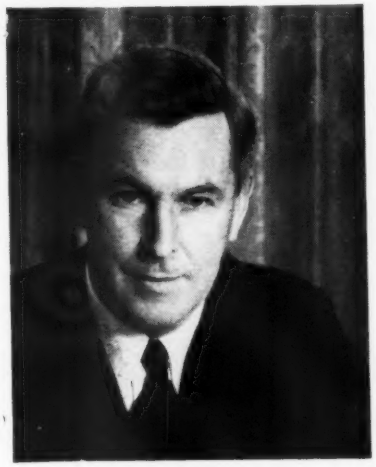
A team representing 40 pct of the private power groups in Sweden made a week's trip to this country recently for talks with the big nuclear groups and visited the sites of Bradwell and Berkeley nuclear power stations. Conversations were held with the Nuclear Power Plant Co and the General Electric, Associated Electric and English Electric groups. The team was headed by Dr Gunnar Lindstrom, of Atomkraft Consortiet and included directors of various Swedish electricity undertakings. The visit was exploratory only but it is reported that the Swedes were deeply impressed with the amount of work that had been accomplished and held discussions on the possibility of building a British-type reactor in Sweden under licence. They took home cost estimates to study.

SIMA urge more Canadian publicity

Recently returned from its Canadian visit (*Companies* last month), the SIMA team pays tribute to the 'traditional hospitality with which they were made welcome in both French and English speaking territories.' Mr Laurie Woodhead, leader of the group, said on his return to the UK on April 14, 'As a result of the talks we had we consider that British scientific instrument manufacturers could with profit get closer as a group or groups to step up active sales promotion in Canada.' The SIMA team gained the impression that a lot more could be done on the publicity side and that stocks of spare parts in Canada could be very much improved. They called for an increase in the number of technical experts on the spot. When all the members of the delegation have returned home they intend to recommend a speeding up in the flow of information about their products for Canadian users.

Changes at Babcock & Wilcox

New Managing Director for Babcock & Wilcox Ltd is Mr Hector McNeil. He succeeds Sir Kenneth Hague who has decided to give up the job which he has held for the last thirteen years, though continuing as Deputy Chairman. Mr. McNeil was born in New Zealand in 1904 and was educated at Canterbury University College, Christchurch. He came to Babcock & Wilcox in London from Australia 27 years ago and has been associated with the company ever since. For the last five years he has been deputy managing director and is closely in touch with the international Babcock & Wilcox organization as a director of the German, Spanish and Australian companies. He is



McNEIL
from deputy to managing director

President of the Institute of Fuel.

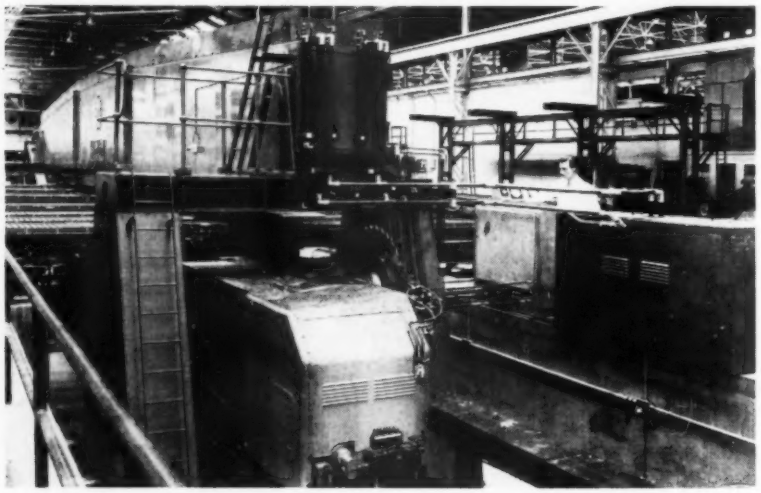
Other changes announced by the company include the appointment of Mr J. Stewart Robinson as a director. He has been general manager since 1953.

£M10 programme for Noral

Many technical problems have been solved in the first instalment of plant for the £M10 expansion programme recently announced by Northern Aluminium Co Ltd. The plan is to increase the capacity of the aluminium rolling mill at Rogerstone, Mon, to 75,000 tons a year with an eye to an ultimate increase to 175,000 at a relatively low cost per ton. Some of the money will be spent on further modernization of the Banbury and Birmingham works. The augmented mill at Rogerstone will be used for the manufacture of a large range of rolled products to meet the needs of the atomic energy, shipbuilding, chemical and other industries. Over £500,000 worth of equipment put into service in the last few weeks for plate up to 55ft long 10ft wide

and 6in. thick includes a heat-treatment furnace for both artificial aging and quenching. It is of the bottom-loading type with a quench tank immediately below the furnace chamber. 'This design was chosen', said a company spokesman, 'as giving the best answer to the problems arising in heat treating aluminium alloy plate of the sizes contemplated.' Manufacturers are Stordy Engineering Ltd.

New approach To relieve internal stresses caused by quenching a stretcher has been installed. This is capable of applying a controlled stretch of 4000 tons pull by the action of two hydraulically operated rams and was built by Loewy Engineering Co Ltd. Also now in service is a Wadkins Ltd high-speed plate saw for accurate finishing which tries a new approach to the difficult question of holding large plates securely during cutting. Surmounting the machine and completely spanning the plate to be cut is a single 20-ton box-section beam 68ft long which carries inside it 18 pairs of hydraulic jacks to hold the plate to the table. They are grouped more closely at the control panel end so that short lengths can be accommodated without difficulty. The plate is cut by a circular saw which travels beneath the beam traversing its length and the saw blade, which has tungsten carbide-tipped teeth, is located beneath the centre of the beam's cross-section and projects upwards between plate conveyor tables.



The saddle carrying the sawing disk traverses beneath the 68 ft 20-ton beam which carries 18 pairs of hydraulic jacks for holding the plate

The basic reason for the expansion scheme, say the company, is to increase the range and lower the cost of products. In the face of increasing competition from abroad and the trend for aluminium fabricators in export markets to build their own plants, more efficient production methods have become essential.

Computer for Norway

Analysis of foreign trade and economic trends in Norway will soon be aided by an English Electric *Deuce* computer. The Central Bureau of Statistics has announced that it has placed an order after getting sanction from the Norwegian Government. Foreign trade statistics are at present analysed using punched card machines, and the introduction of the computer will speed up the preparation of the numerous tables and summaries required. It is to be a regular monthly task and should be a help to the various businesses and government organizations which base decisions on these figures. Mathematical analysis of various statistics will also be undertaken with a view to spotting important influences and establishing economic trends. In addition it will be put to work analysing the Norwegian census of population, and it is hoped that this will make the analysis more thorough in the future.

Any spare time on *Deuce* will be offered to commercial and scientic organizations and processing of problems will be helped by British experience. Programming work compiled here will be made available to all Norwegian users.

German furnace details

More details of William Jessop & Sons' new consumable electrode arc-melting furnace, which was reported in last month's *Companies*, are now available. The 43-ft high furnace is suitable for melting ingots of titanium, zirconium or steel under a working vacuum of approximately 0·01mm Hg or under inert gas at reduced pressure. Uses of steels produced by this technique, say the manufacturers, W. C. Heraeus of Germany, include ball bearings for nuclear reactors and alloys for gas turbines. The melting of the electrodes takes place in a water-cooled copper crucible and the regulation of the electrode feed, which presents rather a problem in the vacuum, as well as the stabilization of the arc is fully automatic. An oil booster pump working in parallel with a Roots pump achieves a total suction speed of 6000 litres per sec at 0·01 mm Hg for air, and nearly double that amount for hydrogen. To reduce liability to dust contamination a fore-vacuum for this high vacuum pumping combination is obtained by Roots pumps and a water-ring ejector pump working in series.

Possible error on the part of the operator is minimized as far as possible by numerous interlocking control arrangements and to enable him to watch the melting process a picture of the arc is transmitted by a teleoptic installation to a viewing screen situated over the control panel.

In brief

The largest beams in Europe will be produced by Dorman Long & Co's new steel mill when it goes into commercial production in July. The first to be built in Europe for over twenty years, it cost £18,500,000 of which £M2 was spent in the US. It will enable sizes of beam available to the engineering industry to be increased to 36 by 16½in., of 20 tons weight. The first to be ordered was rolled on April 10.

A Burmese Trade Delegation recently spent a few days in this country and visited several firms, including the Southend-on-Sea works of E. K. Cole Ltd. The team was headed by the Burmese Minister of Industries accompanied by the Burmese Ambassador in London. In the company of Mr. E. K. Cole, Chairman and Managing Director of the firm, they toured the electronics, plastics and other factories.

Two American scientists from the Massachusetts Institute of Technology have patented another device for direct conversion of **heat to electricity.** It incorporates a metal anode and cathode sealed into a vacuum tube and appears to be basically similar to the device invented last year by Dr Volney Wilson of the US General Electric Co, but conversion efficiencies of 12 pct are claimed. It is reported that efficiencies of the order of 30 pct are believed to be ultimately attainable leading to its use with nuclear or other fuels.

An agreement has been reached for Solartron Electronic Group Ltd to sell some products of Ericsson Telephones Ltd. Arrangement will be world wide except for Scandinavia and South Africa.

Books on Welding

HANDBOOK FOR WELDING DESIGN

The first volume of a three-volume work on the design of products fabricated in mild or low-alloy steels by metal-arc welding—fundamental data. xvi + 305 pp. 45s. postage 1s. 6d.

PROCEEDINGS OF THE FIRST BRITISH COMMONWEALTH WELDING CONFERENCE, LONDON AND SALTBURN-BY-THE-SEA, JUNE 1957

Sixty papers, illustrated, with full report of discussion. About 400 pp. Ready in May. 105s.

BRITISH WELDING JOURNAL – ORGAN OF THE INSTITUTE OF WELDING AND THE BRITISH WELDING RESEARCH ASSOCIATION

Monthly. Subscription (12 issues) £5 postage 14s.

CONTROL OF WELDING DISTORTION

37 pp. 5s.

HEALTH AND SAFETY IN WELDING

55 pp. 3s.

THE INSTITUTE OF WELDING

54 PRINCES GATE · LONDON · S.W.7

Cross Section by GRACCHUS

DOWN AT EASTBOURNE for the FBI's conference, I thought I detected a cool wind blowing down the Victorian corridors of the Grand Hotel, and this had nothing to do with the keen nor'easter that was raking the promenade outside. It wasn't that the delegates were depressed or disillusioned—indeed Sir Edwin Plowden's excellent speech soon put them in good spirits—but there was undoubtedly a general soberness about the whole business and a realistic appraisal of the very real opportunities in nuclear energy. This, of course, is all to the good and the sooner it is 'deglamorized'—in Sir Claude Gibb's expressive phrase—the better.

I was told that applications for membership of the conference had to be severely limited and that the organizers tried to get a good representation of 'fringe' firms—in other words companies that are equipped to supply the main contracting firms but are not yet doing so, or those who are potentially users of isotopes. Certainly there were several in this category but there were also a lot of delegates to whom some of the papers must have seemed pretty elementary. No doubt in a conference of this nature it is a good idea to have a sprinkling of experts to mix along with the others, but this one I felt was tilted a little too far this way. Nevertheless it was a great success and I hope the FBI will be emboldened to hold further conferences of this kind.

At the dinner the only positive suggestion came from the Mayor of Eastbourne, Alderman Caffyn. He pointed out that many science and engineering graduates came from the South Coast and the Eastbourne area in particular but that after leaving school for the universities they seldom came back to the district, which of course was a bad thing for the community. Alderman Caffyn said he'd noticed many large companies were now setting up research laboratories and design offices away from their works and he could think of no better place than the South Coast, for the pleasant working conditions there would probably do more than anything else to attract the best men. I think there's a lot in this. One has only to look at American magazines to see what he means—'Come and work at L—— A—— in pleasant New Mexico', 'Live in sunny California and join. . . .' The Authority seem to have realized this long ago and while it remains difficult to get men to settle in Warrington and Wigan it is all too easy at Winfrith Heath! Many research organizations are centred at Leatherhead—an uneasy halfway house—so why not go the whole hog and set up where you get the most of the sun? I would seriously commend the Mayor's idea to firms thinking about new developments.

WHEN I HEARD this issue was to be a welding symposium I realized that, not having the benefit of a classical education, I simply did not know what the word really means so I shot off for a dictionary and had a most delightful shock. I wonder how many engineers are really clear about these curious functions which sometimes take them away from hearth and home? Briefly, the word derives from the Greek *sym-* (together or along with) plus *posis* (drinking). In other words a symposium, properly speaking is, in the words of the Concise Oxford Dictionary, 'an after dinner drinking-party with music, dancers or conversation. . . .'! Well, I have been at symposia which did live up to this although most are flagrant denials of this definition.

THE ACHIEVEMENT of Texas Instruments in setting up a complete new transistor factory at Bedford has called forth quite a lot of admiration. I was amused however to see in their employee magazine—published in Dallas, Texas, of course—a photo of some girls arriving at the Bedford works. In itself this would hardly have caught one's notice—it showed merely four girls dressed in macs and holding bicycles, with one more hardy than the rest on a real man-sized motorcycle. It was the caption that took my fancy, 'Illustrating typical British transportation and summer weather in England. . . . .' I suppose however to a Texan it's no more amusing than a shot of Tibetans posed outside a lamasery.

I SHOULDN'T have been, but I was, surprised to learn that the chief of the Shippingport PWR project was none other than Admiral Rickover of *Nautilus* fame. As all the world now know this reactor went critical with a rare American consideration of date significance—on Dec 2, 1957, or just 15 years to the day after Fermi's first pile in Chicago. The amount of press information released on the PWR is simply staggering and I calculate it would need about three complete issues of NUCLEAR POWER to carry it all. The cost I notice is now put at $121,400,000—$98,400,000 from the US Government, $22,500,000 from Duquesne Light (who will operate the plant and sell the electricity) and $500,000 from Westinghouse. Some $48,000,000 of this is accounted for by research and development, the rest being the actual construction cost and fuel. Unit costs, neglecting R & D, come out at 64 mills per kWh assuming 60 MW at 80 pct load factor.

These are very high figures but Shippingport just had to be built and we should be grateful for not having to do this expensive experiment.

On Record

It is impossible with the scientific knowledge available to us to ascertain what proportion of what meat there is in a sausage. Mr John Hare, Minister of Food and Agriculture.

Our ignorance is pitiable. Man has mastered the release of atomic energy long before he has the knowledge to assess its biological consequences. Dr Cecil Gordon, Edinburgh University.

ZETA, *I take to be a tremendously ingenious and practical machine for making a very hot heat inside a doughnu'.* Miss Siriol Hugh Jones, 'The Sunday Times'.

A young man who is a graduate engineer is today the most saleable commodity in the world except, possibly, a bar of gold. Lord Chandos, Chairman of AEI.

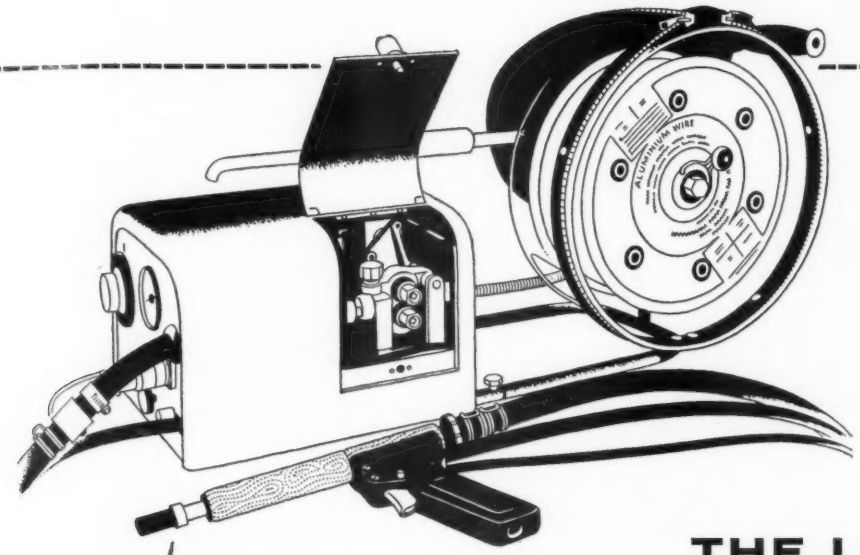
The arrival of nuclear energy does not solve the fuel problem which Western industrialism, and particularly that of Western Europe, will have to face over the next 40 years, if current ideas of perpetual cumulation economic growth should be pursued. Mr E. F. Schumacher, Economic Adviser, National Coal Board.

Because of the technological difficulties associated with the building of these (fast) *reactors it appears that their importance is not as great as was at first thought.* Dr D. J. Littler, Harwell.

Economic competitiveness of small reactor units could be demonstrated if manufacturers would make a concerted effort to get reactors out of the Cadillac into the jeep class. C. M. Rice, Atomic Engineering Division, American Standard.

Tick **No 74** on reply card for further details

FROM BRITISH OXYGEN — FOR BRITISH INDUSTRY



THE LYNX

a new development in inert gas welding

This new British built LYNX inert gas consumable electrode welding set incorporating the best features of Argonaut and Sigma is an important new development in the Argon welding field.
It is a bare wire consumable-electrode unit with a new power source and the choice of two torches—an air-cooled for site work and low current consumption, or water-cooled for welding metals where the current requirements are in excess of 300 amperes.
Currents as high as 500 amperes can be used for continuous operation, and up to 600 amperes for intermittent welding.
Other advantages of this new equipment are: a totally enclosed carriage which is light, compact and robust; an improved feed roll assembly providing a positive drive, with a remote control box for the manual control of welding wire speed.
In addition, the control box housing relays are located in the power source; the thermostat is built into the water-cooled power cable which protects the equipment from damage; and the design of the relays has been improved.
Available for argon shielded welding from your nearest British Oxygen Gases branch or from the makers Quasi-Arc Limited, Bilston, Staffordshire.

BOC **BRITISH OXYGEN**

British Oxygen Gases Ltd.
Industrial Division, Spencer House,
27, St. James's Place, London, S.W.1.

Is the nuclear programme too big?

Annual exports of nuclear power plant in the years after 1965 may only be as large as our current export of ships and smaller than our current export of aircraft and aero engines, according to two economists, J. R. Cuthbertson from Lazard Bros & Co Ltd and J. Brodrick of the English Electric Co. Their paper on financial and investment aspects of nuclear energy was read on April 10 at the FBI conference on nuclear energy at Eastbourne, and included a survey of prospective exports based on considerations of future overseas demand, known possible projects, the likely capacity of the UK industry and possible overseas competition. They concluded that we may expect orders for six to eight nuclear power stations mainly around 150MW output in the next three years, located principally in continental Europe. The build up of nuclear plant on the continent is likely to be slow at first and gather speed in the mid-1960's when European firms themselves will be able to build a large proportion of the continent's needs. However royalities and fees from licensed British designs will begin to become important in our export earnings and a considerable amount of hardware is still likely to be exported from the UK, though this will tend more and more to be specialized equipment such as charge/discharge machines, control equipment and monitoring devices which either require special and expensive machines to produce them or in which we are likely to have a technical lead in design. Our share should produce exports of about £M35 a year in the five years from 1961 and orders from the rapidly industrializing Dominions and the North American continent should bring in another £M30 a year exclusive of fuel.

UK lead not indefinite The big markets of the world in the ten years after 1956 will still be in Europe and North America but these countries will tend to be increasingly self sufficient, importing only a relatively small margin of nuclear equipment. We must expect competition from firms in the US and Germany and possibly France. 'If the industry in Great Britain should maintain a commanding technical lead our estimate for the future could be far too pessimistic,' said the authors, 'but it seems only realistic to suppose that technology is now far too complex and offers far too many opportunities to the fertile human brain for any one nation to hold a commanding lead in any one field indefinitely.'

In addition to Europe and North America in this period sizeable demands will be arising in Asia, Africa and Latin America and total installation of nuclear plant should average about 15,000 MW a year, but our share is only likely to amount to about £M85 a year exclusive of fuel. This estimate is based only on a broad survey of energy requirements, and ignores the possibility of the USSR entering the field—'we have not dared to speculate on this' they said—but their researches have found a broad unanimity in published opinions of experts on energy requirements.

International trade in reactors outside Europe and America will be on a comparatively small scale for ten or fifteen years to come, they think, simply because the places at which nuclear power will be an economic proposition within that time are so limited in number, one reason being the low load factor in many countries of the world. On the other hand the cost of power from thermal stations is greatly increased by the cost of transporting fuel over long distances, and outside Europe a distance of 300 or 400 miles from a source of conventional fuel is nothing out of the ordinary. The authors calculated that the increase in cost of power from thermal stations caused by an extra 300 miles is actually equal to the increase in cost of nuclear power caused by a change from 2¾ to 11 pct in the rate of interest at which the necessary capital for construction can be borrowed. In view of the very great effect of interest rates on the cost of nuclear power—a point emphasized again and again in the paper—they conclude that the prevailing rate of interest will be supremely important when considering the siting of atomic energy plants. 'More important perhaps,' they add, 'it makes one wonder whether some modification is not required in current views regarding the parts of the world in which atomic energy is likely to prove competitive.'

Costs artificial The paper stresses the difficulty of deciding what priority should be accorded to finance for the nuclear energy programme when interest rates, coal and electricity prices are all 'artificial' in this country. There is always a danger that decisions to install nuclear plant in preference to conventional sources of power may be based on calculations favouring the former unduly because they incorporate an artificially low interest rate. 'If the CEGB had to pay a competitive rate of interest for its money it would make it think twice before choosing to install atomic energy of double the capital cost of conventional plant per unit of capacity,' they said. Capital resources are scarce and there are many clamant and highly profitable uses for it. 'It is natural therefore to ask whether the UK may not be devoting too much of her resources to the building of 'Mark I and II' nuclear power stations. The authors confessed their inability to give a complete answer because it involves scientific and strategic as well as economic considerations. Even as economists they are up against the uncertainty of the future cost of coal, which is a powerful factor. They concluded that the decision to go bald-headed for nuclear energy is probably right on both strategic and cost grounds, but 'the authorities are reticent, to say the least, about showing in published statements that they are aware of all the relevant economic considerations and have taken them into account.'

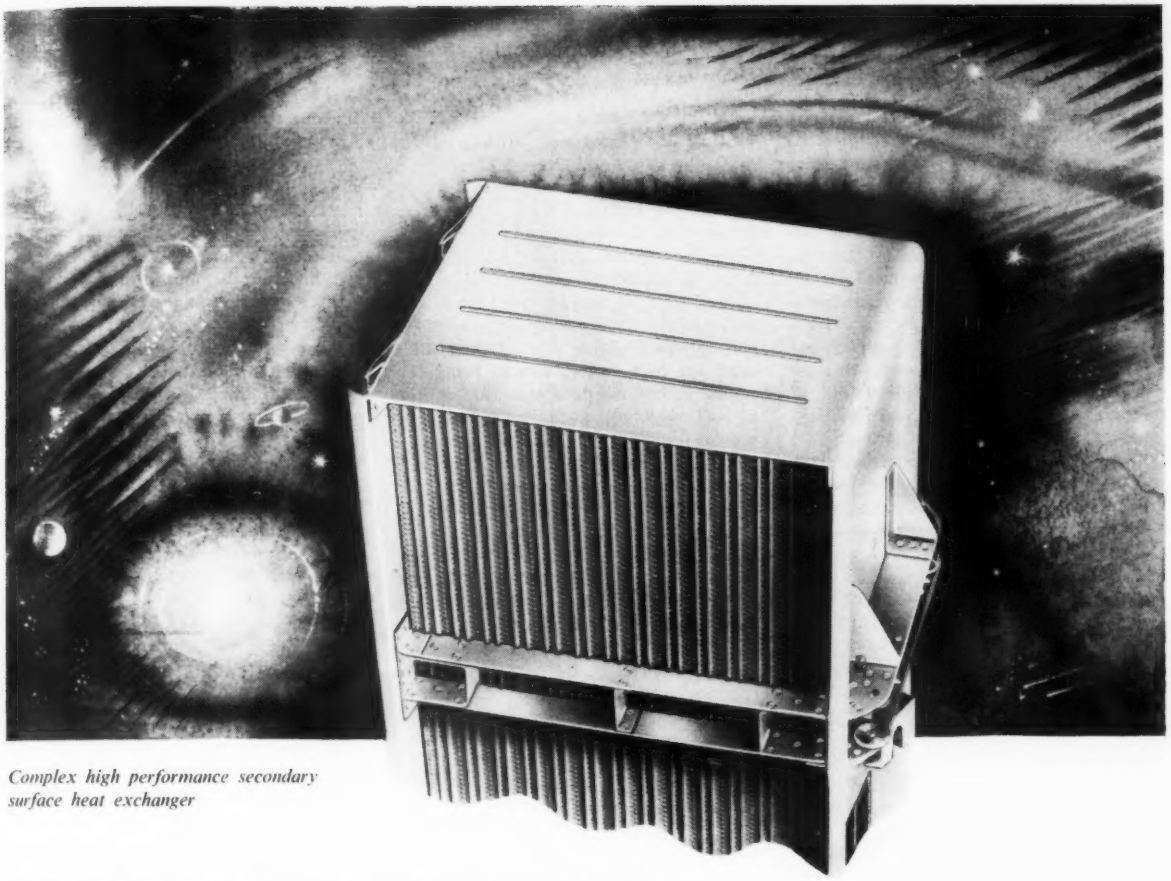
The objective for Euratom

The benefits of replacing traditional by nuclear fuels will be lost if the Euratom countries have to go abroad to buy the plant required, and in spite of assurances

GIORDANI
Our industry is 60 pct larger than UK

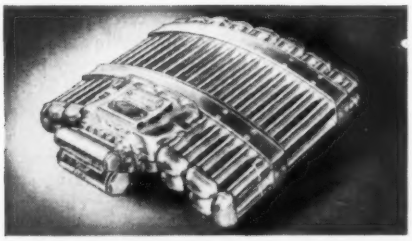
by American and British manufacturers that they can supply all the plant needed for the nuclear energy programme the committee has never lost sight of the fact. This was stated by Professor Giordani, President of Italy's National Research Council and one of the 'Three Wise Men' committee, in a lecture given to the Institution of Electrical Engineers recently. The Euratom target for 1967 was two and a half times as much as the British one, he said, while the ratio of population was 3 to 1 and that of electricity output was 2·8 to 1. British manufacturers have stated that within the next ten years they will be in a position to supply the 6000 MW for their national programme and also export all the machinery required for an equal amount of power. But since an OEEC investigation has shown that the mechanical and electrotechnical industries of the six Euratom countries have a 60 pct greater total capacity than the UK industries they

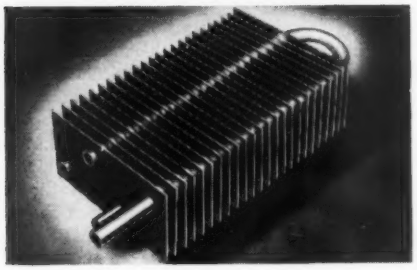
Tick **No 75** on reply card for further details



Complex high performance secondary surface heat exchanger

Aluminium Flux Bath Brazing makes the impossible possible





The tremendous advantages of aluminium dip brazing are at last readily available. The finest plant in the country is at your service.

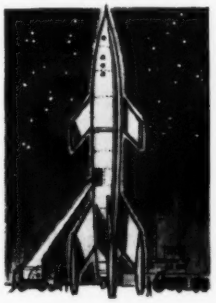
Dip brazing makes the impossible possible. Design inaccessible joints—as many as you wish. Use aluminium as thin as foil. Think in terms of very close tolerances. All these things you can do. And you can combine them in units so small, so light and so efficient that it would be *impossible* to make them by any other method.

Designing for dip brazing need present no problems. We shall be happy to design for you, or if you prefer it, to discuss possibilities with you and then work to your design.

If you would like to know more about what can be done by this process please contact us. We are specialists in all types of brazing and welding.

Above: *Fuel cooled oil cooler for high performance gas turbine engines.*

Below: *Typical example of industrial heat exchanger.*



Delaney Gallay LTD

Specialists in heat exchange and heat insulation for the aircraft, automobile and marine industries.

Vulcan Works, Edgware Road, London, N.W.2. Telephone: GLAdstone 2201

should be able to supply within ten years the equipment needed for nuclear power stations producing a total of 15,000 MW.

The possibility of a rapid start on a nuclear energy programme was supported by the successful operation of the Calder Hall plants in the UK and its urgency is underlined by the tremendous cost of importing power. These imports are estimated as going up to 282 million tons of equivalent coal in 1957 to meet the 80 pct increase in power consumption in the six countries during the 20 years from 1955 predicted by a committee of experts last year. The target of releasing through nuclear plants some 40 million tons of equivalent coal as conventional fuel eight years earlier than 1975 through the efforts of the Euratom countries alone was an ambitious one but it was justified when it was recalled that the programme outlined in the UK white paper had been increased threefold, from 2000 to 6000 installed MW.

In Western Europe the growth of available resources does not keep pace with consumption so that there is an anxious search for new and abundant power sources. 'All our hopes are now pinned on nuclear energy,' he said.

AGR on the way

The AEA seems to have finally decided against liquid-cooled reactors. The results of a detailed design study on the sodium graphite reactor and a research study on the PWR carried out in the last three years are not encouraging; the possible economic advantages of the former are outweighed by its serious development and maintenance problems, and the PWR is not favoured because enriched uranium fuel produced in any European country would be much more expensive than in the US. Sir John Cockcroft, giving the James Forrest lecture to the Institution of Civil Engineers recently, said that the Authority is therefore definitely concentrating on the advanced gas-cooled graphite-moderated reactor (AGR) while investigating the possible advantage of a change to heavy water as a moderator.

Beryllium cans probable 'The object of the AGR is to decrease capital costs by the order of 30 pct,' he stated. The idea is to increase average ratings to 8 MW thermal per ton by using clusters of small diameter fuel elements, and letting the surface temperature go up to 600°C. Uranium metal will be abandoned in favour of sintered uranium oxide which has a melting point of 2400°C and very good irradiation stability. It will probably be canned in beryllium, and he revealed that specimen sealed beryllium cans have already been thermal cycled hundreds of times through the alpha-beta change point without damage. 'A first specimen is now going into our DIDO reactor to determine their overall irradiation stability,' he said. Nuclear properties of the AGR are already being studied using a zero energy reactor NERO.

Something would have to be paid for the high ratings and the use of uranium oxide, and the proportion of U-235 will have to be increased slightly, but it is hoped that the greater irradiation stability and higher efficiency will result in twice the amount of heat per ton so that the overall fuel cost can be kept to the same as the first generation reactors—about 0·16 pence per unit. On the other hand the high ratings should bring the capital costs down to about £80 per kW so that with the load factors of about 70 pct predicted for the late 1960's, overall costs should come down towards the 0·47 pence per unit prophesied by Sir Christopher Hinton for 1970. 'This at least is our target,' emphasized Sir John.

The ultimate development of the gas-cooled reactor would substitute all ceramic fuel elements for the designs using metal sheaths and this might allow outlet gas temperatures to be increased to about 700°C resulting in further increases of ratings. Research is going on to develop impervious ceramic sheaths for a mixture of graphite, uranium and thorium as a fuel element.

A promising alternative to the AGR is the heavy water-moderated gas-cooled reactor. 'We believe that following the technological work on heavy water production at Harwell during the last few years it would be possible to produce heavy water here and in other European countries at the present US price of £20,000 per ton,' said Sir John. Smaller reactor size would offset the cost of heavy water and it ought to be possible to achieve capital costs of £80 per kW in large outputs of say 500 eMW of which between £10 and £15 per kW would be contributed by the heavy water. Fuel ratings would be similar to those of the AGR whilst because of the favourable neutron economy only slight enrichment of fuel would be needed and fuel costs would be lower.

Dounreay caution Turning to fast reactors, Sir John commented that now uranium available to the West is over 30,000 tons a year the original urgency for developing them has largely disappeared. 'In the course of the design we have come to appreciate more fully its difficult technological and safety problems, so we will proceed cautiously with its operation and development and will not expect it to play a major part in our programme before the 1970's,' he said.

1962: nuclear power the cheapest

If development of nuclear power stations can be continued at its present rate and if coal costs continue to go up nuclear power will be cheaper than power from conventional stations by 1962, forecast Sir Christopher Hinton recently, and by 1982 it will be less than half as dear. This prophecy was made in his Trueman Wood lecture to the Royal Society of Arts and he based it on a survey of efficiency trends in conventional prime movers in the past and recent developments in nuclear engineering. While reasoning that conventional stations will become more efficient he argued that this was likely to be offset by the growing cost of mining coal and estimated that this would lead to an actual increase in the cost of electricity produced by these stations from 0·62 to 0·8 pence per unit by 1982. But such a development would not lead to a reduction in the overall demand for coal, he thought. This demand is rising far more rapidly than supplies are expanding, and the report of the OEEC committee which studied this problem showed that there would be a large and growing gap which could only be met by the growing use of oil and nuclear power.

Uskmouth mystery solved

The causes of the catastrophic accident to the No 5 60 MW turbogenerator in the Uskmouth Power station in January 1956 have been established and the results were presented in a recent paper to the Institution of Mechanical Engineers by A. L. G. Lindley, Assistant General Manager of the GEC, and F. H. S. Brown, CEGB Chief Engineer. Two men lost their lives when the low pressure turbine and generator completely disintegrated.

A working party was at once set up, though the damage was so extensive that it seemed by no means certain that firm conclusions as to the ultimate cause could ever be drawn. However by a quite remarkable piece of detective work it has been finally established that the reasons for failure centred on the presence of black iron oxide in the oil system which built up on working surfaces of pistons and cylinder bores, resulting in seizure of the power piston of the primary governing relay. Some warning was given by deterioration of governing performance, but this was construed as a transitory stickiness in operation (the set had only been in service for eight weeks), and there was no realization of how rapidly a dangerous state could be achieved.

The formation of black iron oxide of very small particle size has been shown to be due to slight contamination of the oil by brackish water, coupled with abnormally long shut down periods. The phenomenon is believed to be unique and its discovery has placed added emphasis on the necessity of actively investigating any observed abnormality in the performance of turbine control and protective devices.

250 SQUARE FEET OF FLAME

OUT-IN ONLY 21 SECONDS

On test the new Nu-Swift 30 lb. powder extinguisher put out 250 square feet of roaring flame almost as quickly as you can read these words. This tremendous speed of attack is the most important single factor in fighting fires involving highly inflammable liquids or live electrical apparatus. Tests have proved it. Post your coupon for full details today.

SPECIALLY SUITABLE FOR USE ON FIRES INVOLVING

- hot, heavy oils
- electrical risks such as oil-filled transformers, switchgear and circuit breakers
- industrial processes in which inflammable solvents are used
- paraffin or inflammable cutting oils
- oil quenching and tempering tanks
- oil-fired boilers, ovens and furnaces
- oil storage tanks
- cellulose spraying booths
- solvent recovery plants
- stores of gas oil, benzol, petrol and paraffin
- garage and transport depots

YOU CAN RELY ON NU-SWIFT

THE FACTS ABOUT THE 1630

* 30 lb. of dry powder, pressurized with 11 ozs. of carbon dioxide which expels the contents at the rate of 1 lb. per second for 28 seconds. * The powder is non-toxic, non-conductive of electricity, non-abrasive, frost proof down to – 40°F., and harmless to machinery. * Easy to operate for untrained personnel, used in the sensible upright position and almost instantaneous in action. * The powder cloud has great heat-shielding properties, enabling even an amateur to tackle a serious fire effectively. * Easily installed, the Model 1630 also reduces maintenance costs. A tell-tale gauge provides instant visual confirmation that the extinguisher is under pressure.

Please let us have full details of the new Nu-Swift Model 1630 dry powder extinguisher.

Name.....

Address.....

For the attention of Mr.

IN THE SOUTH to Nu-Swift Limited, (Dept. No S380) 25, Piccadilly, W.1. (REGen 5724)

IN THE NORTH to Nu-Swift Limited, (Dept. No N380) Elland, Yorkshire. (Elland 2852)

(NP5)

BOOKS

Reactor types

Reaktortechnik P. R. Arendt, Physikalische Schriften Vol 5. Mosbach/Baden 1957: Physik Verlag. 198 pp. Price DM19.20

The largest section of this small volume is a description of different reactor types including natural uranium, research, materials testing, breeding and fast reactors. Detailed accounts are given of the principal features of actual reactors falling into these categories.

As an introduction to this part of the book there are two chapters on elementary physics. (It might be noted that there is no introduction to the engineering problems of reactors.) The first of these chapters describes the facts of nuclear physics which are necessary for an understanding of how and why a nuclear reactor can maintain a chain reaction. There is also a small section on thermonuclear reactions. The second chapter discusses chain reactions in general and the multiplication constant in particular, in addition to some properties of the materials used in reactors.

A short account of reactor control is followed by the other main section of the book which deals with the general problem of reactor safety. This section, after an introduction on the need for health and safety precautions, describes some of the problems connected with reactor shielding, exhaust coolant gases and activity from coolant stacks, and radioactive waste disposal.

The final chapter relates to the economics of reactors with special reference to Western Germany.

J. F. Hill

Reactor wear

Corrosion and wear handbook Editor D. J. De Paul New York 1957 : McGraw-Hill Book Co Inc 293 pp 45s.

This summarizes a section of the work on corrosion and related phenomena carried out in the United States as part of the development of nuclear power for the US Navy. It deals with most of the materials used in the primary circuit of a water-cooled reactor with the exception of the fuel elements and control rods. An indication of the problems encountered can be illustrated by quoting directly from the Foreword by Admiral Rickover: 'But it turned out that even a technology so well developed as water required a great deal of additional work specific to the peculiar conditions of a nuclear power-plant; this book, containing information developed through the expenditure of millions of dollars, and thousands of man-years of effort is evidence of the extent of that work. In spite of this work our basic understanding of water technology is weak. We do not fully understand, for example, the processes by which metals become dissolved or suspended in the reactor cooling water.'

The handbook is divided in three parts. Part A gives background information and general principles for the benefit of engineers and scientists who are encountering for the first time the problems associated with the use of high purity, high temperature water as a reactor coolant. This information is intended to help them evaluate new problems encountered in this field.

Part B contains tabulated data and detailed information for use as reference material for actual design work. Numerous references to additional data are included, but no indication of the meaning of 'malcomised' (*q.v.* page 104, probably nitrided).

Part C contains material on special types of corrosion and problems involving wear. Discussions and detailed data on crevice corrosion, stress corrosion, intergranular corrosion, system corrosion deposits, wear and manufacturing problems are included.

In a volume of this nature some heterogeneity is inevitable, but it is well edited and the many authors have combined to give the reader some idea of the problems that might be encountered in the development of a similar plant. A careful study of its pages reveals the immense scientific and technical effort that has gone into the work. For example, in chapter 5, the techniques of testing materials at high temperatures and pressures are reviewed. Even with no mention of any safety devices, such as bursting disks, the apparatus is complicated.

With many critical eyes focused on the United Kingdom power programme, based as it is on gas-cooled reactors, it is timely that a volume like this should appear, showing a few of the problems associated with the water-cooled system. A comparison of similar problems in the two systems certainly suggests that the UK chose the easiest, and the most appropriate route for its initial requirements of nuclear power.

J. F. Hill

No stone unturned

Engineering Materials Handbook Ed. Charles L. Mantell. ca. 2000 pp. London 1958: McGraw-Hill Price £8 7s.

In the matter of voluminous compilations the Americans have, since the war, completely taken over from the Germans which of course makes it much easier for the average British reader, whose prowess in foreign languages is generally nothing to shout about. A typical example of this sort of activity is McGraw-Hill's latest handbook—a volume of imposing thickness which explains its very high cost. In its compilation, Dr Mantell has assembled no less than 150 specialists who are all experts in their own fields and they certainly seem to have left no stone unturned.

A book of this size and scope really defies reviewers: the only test is to see how it works when you actually need it and it is surprising how many handbooks fail in this test. We have done one or two spot checks of this nature and the Handbook certainly seems to work. It does not however claim to have any particular nuclear slant—uranium and plutonium, for example receiving little more than a mention. Beryllium however is well dealt with by B. R. F. Kjellgren of Brush Beryllium and similarly zirconium by W. E. Kuhn of Carborundum Metals. Nevertheless, for ordinary engineering materials the treatment is exhaustive and minute.

The book is arranged in 43 sections covering metals, concretes, ceramics, glass, wood, textiles, rubbers, plastics, corrosion, etc. But in a review of this length it is impossible to do more than merely indicate the general scope. The cost of the book will probably price it out of most individuals' pockets but it should certainly be on the shelves of any engineering library worthy of the name. Its production and printing are all that one has come to expect from this publisher.

W.D.

Bigger than ever

The BEAMA Catalogue 4th Edn. London 1958: British Electrical and Allied Manufacturers' Association

Atomic energy is of course still only a small part of the country's gigantic electrical industry but it is gratifying to see its importance being emphasized by so many firms in the new edition of the BEAMA catalogue. Bigger and fatter than ever, it includes a useful five language glossary of engineering terms. Sir David Eccles, President of the Board of Trade, contributes a foreword.

Shell lends a hand at Dounreay

Lubrication conditions at Dounreay are particularly severe. As the site is too remote to tap the National Grid, the nuclear research installation is completely dependent on the 200 b.h.p. diesel electric sets. These sets *will have to be absolutely dependable at all times*. There is no second string.

Absolute dependability being largely a question of correct lubrication, the Atomic Energy Authority called in Shell for advice. After comparative lubrication tests, the A.E.A. chose Shell RIMULA Oil 30—a very heavy duty oil.

The moral of the Dounreay story is that Shell can work with even the most specialised sectors of industry to provide the right oil for the job. If dependable lubrication is your problem, it pays to get in touch with Lubricants Department, Shell-Mex & B.P. Ltd., Shell-Mex House, Strand, London, W.C.2.

SHELL LEADERSHIP IN LUBRICATION

NAMES IN THE NEWS

F. FAUX

P. H. G. NEWHOUSE

P. H. SYKES

C. H. FLURSCHEIM

Mr Frank Faux, chief assistant engineer to the system planning engineer of the Central Electricity Generating Board has been appointed station planning and development engineer of the Board.

After 47 years with the Siemens group, **Mr W. H. Grinsted,** director of engineering of Siemens Edison Swan Ltd has now retired.

Mr Philip Sellars has joined the board of Southern Instruments Ltd. He will be responsible for overall coordination of the activities of the Company.

Mr H. F. Wilson and **Mr C. L. G. Fairfield** have been made directors of The Telegraph Construction & Maintenance Co Ltd. Mr Wilson will also shortly become managing director of the Telcon Cables Group.

Mr D. R. C. Guttery has joined the nuclear engineering division of John Brown and Co Ltd as chief engineer. He was previously assistant chief engineer in the AEA civil reactor design office.

Mr H. Pickard has been appointed a director of the APV Company.

Sir John Woods, GCB, MVO has resigned as chairman of the Board of Trade's Advisory Committee on the Revolving Fund for Industry. Sir John is also a director of English Electric.

The CEGB have appointed **Mr L. F. Miller,** deputy chief contracts officer, to be chief purchasing and contracts officer of the Board. **Mr A. McLellan,** deputy accountant of the North West, Merseyside and North Wales Division of the CEGB has been made divisional accountant for the area.

20th Century Electronics Ltd announce the appointment of **Mr A. Richard Gardner** as chief chemist in their Stable Isotope group. Mr Gardner was formerly works manager at De la Rue & Co and assistant general manager of Burndept Ltd.

Dr P. H. Sykes, a director of the British Oxygen Co Ltd has been elected chairman of the Low Temperature Group of the Physical Society.

Mancuna Engineering Ltd announce the appointment of former southern area manager **Mr R. A. Le Page** to their board. He is succeeded in the southern area by **Mr N. S. Stedman.**

Philips Electrical Ltd have made the following appointments. **Mr J. D. Callaway** as manager of the Cardiff branch. **Mr D. H. Clark** as television and radio manager, south-west region, Bristol, and **Mr A. D. Shillabeer** as electrical appliances manager, south-west region, Bristol.

Mr C. H. Flurscheim, chief electrical engineer of Metropolitan-Vickers Electrical Co Ltd has been made a director of the company. **Mr O. T. Evans** has been appointed chief engineer, electrical general engineering department of Metropolitan-Vickers.

Two British scientists—**Dr Malcolm Daniels** and **Dr Donald Smithies** are at present working in the Argonne National Laboratory on a temporary US-Great Britain exchange basis.

Captain J. A. Creed sales manager of Robert Boby Ltd has been appointed deputy managing director.

Everett R. Holles, formerly assistant to Lewis Strauss, chairman of the US AEC has joined the General Atomic Division of General Dynamics Corporation as assistant to Dr Frederic de Hoffman, vice president.

Mr Peter H. G. Newhouse has been appointed by SIMA to the newly created post of press secretary and public relations adviser.

CATALOGUES & BULLETINS

Stainless steel tubes and fittings are described in leaflets from Talbot Stead Tube Co Ltd.
Tick **No 151** on reply card

Booklet from The Minerva Detector Co Ltd explains and illustrates the uses of their nucleonic fire prevention system.
Tick **No 152** on reply card

Diphyl a heat transfer medium manufactured by Farbenfabriken Bayer, available in liquid and vapour form, is subject of 50 page book of diagrams and technical information.
Tick **No 153** on reply card

New leaflets from Sunvic Controls Ltd give details of their 1·1 pressure transmitter (diaphragm type) and a constant differential relay.
Tick **No 154** on reply card

Catalogue with photographs of each model of their geared motors and speed reducers has been issued by Electropower Gears Ltd.
Tick **No 155** on reply card

Tensator Ltd have issued details of a spring which it is claimed gives constant tension for extensions ranging from zero to over a hundred feet.
Tick **No 156** on reply card

New pump brochure from British LaBour listing their type UPL/UHL pumps has handy pump selection chart.
Tick **No 157** on reply card

Everything X-ray is the title of a substantial catalogue published by Cuthbert Andrews, which includes details of their protective glass, lead aprons etc.
Tick **No 158** on reply card

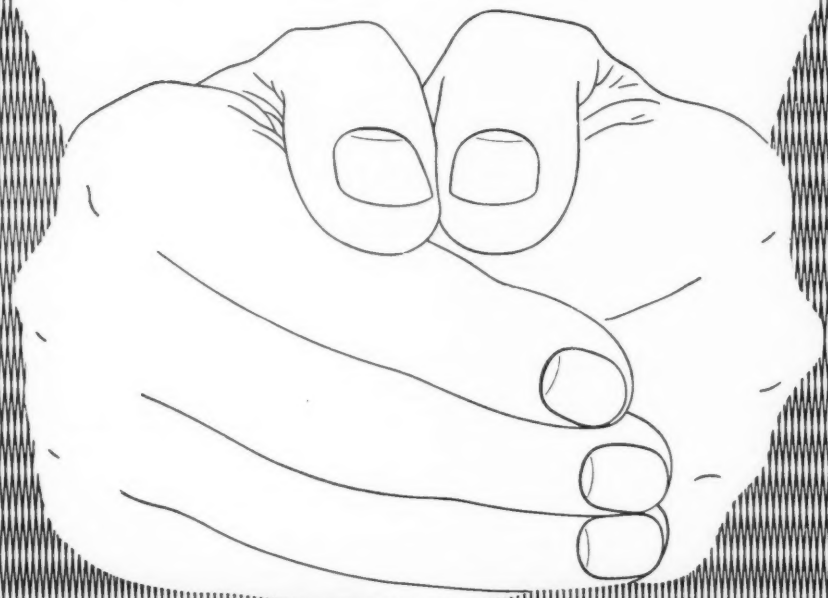
Mullard Educational Service have brought out a booklet on semiconductors and some of the devices in which they are employed. The properties of germanium and its processing are also described.
Tick **No 159** on reply card

Heat exchangers of all kinds are described and illustrated photographically and diagramatically in a folder of leaflets from Heat Exchangers Ltd.
Tick **No 160** on reply card

Current edition of 'Cambridge News' issued by Cambridge Instrument Co Ltd includes notes on standard resistances and a portable oxygen meter.
Tick **No 161** on reply card

Tick **No 74** on reply card for further details

Problems of reactor fuel replenishment, and indeed the safe control of fluids generally, should be referred to the Company best equipped to supply a practical solution.
The **Servicing Dome,** for example, which we are producing, allows a self-locking seal plug to be inserted in the stack pipe to permit the clear bore coupling to be changed for servicing.
Your enquiries for equipment of a similar nature are invited.



FR

Flight Refuelling Ltd

RINGWOOD ROAD · WEST HOWE · BOURNEMOUTH · HANTS · Telephone: Blandford 501. Telegrams: Refuelling, Blandford

RESEARCH REPORTS

The following reports have been made available to the public by the United Kingdom Atomic Energy Authority. They may be borrowed or photocopies obtained from the Science Library, London, Department of Industrial and Forensic Science, Belfast, the Mitchell Library, Glasgow, and the Central Libraries at Acton, Birmingham, Bristol, Kingston-upon-Hull, Leeds, Liverpool, Manchester, Newcastle-upon-Tyne and Sheffield. They are also deposited in the Copyright Libraries (i.e. British Museum; University Library, Cambridge; Radcliffe Science Library, Oxford; National Library of Scotland, Edinburgh; National Library of Wales, Aberystwyth) and in the Patent Office Library. Reports marked may be purchased from Her Majesty's Stationery Office.*

Reports are also available in the United States, from the USAEC depository libraries, a list of which will be found in NUCLEAR SCIENCE ABSTRACTS. Reports for sale may be purchased in the United States from: Sales Section, British Information Services, 30 Rockefeller Plaza, New York 20, N.Y.

AERE Harwell

A method for the direct determination of very low dissociation pressures. *R. W. M. D'Eye, P. G. Sellman.* (Dec 4, 1952. 4 pp) AERE C/R 1077 1s 2d*

The inelastic scattering of cold neutrons by crystals. Part 2. Experiment. *P. A. Egelstaff.* (April 24, 1953. 28 pp) AERE N/R 1165 4s*

Some experiments on rates of transfer of nitrates between an aqueous and a tributyl phosphate phase. *H. A. C. McKay, D. Rees.* (June 1953. 9 pp) AERE C/R 1199 1s 9d*

The cooling of underground fission wastes. *J. K. Perring* (Nov 9, 1953. 11 pp) AERE C/R 1294 2s 6d*

Square wave polarography. Part 2. Notes on the use of the square wave polarograph. *G. C. Barker, D. R. Cockbaine.* (Dec 3, 1954. 27 pp) AERE C/R 1404 4s 6d*

Polarographic theory. Part 1. The influence of non-uniform mercury flow and intermittent polarization on the diffusion current. *G. C. Barker.* (Nov 15, 1954. 13 pp) AERE C/R 1553 2s 6d*

Square wave polarography. Part 3. Single drop polarography. *G. C. Barker.* (Nov 27, 1954. 19 pp) AERE C/R 1563 3s*

Xenon poisoning following changes in reactor power, and their effect on reactivity. *W. Macrae, R. Parr* (Jan 1954. 25 pp) AERE ED/R 1590 4s*

Helium-3 fast neutron spectrometer. Part 3. The gas filling system. *R. Aves et al.* (Jan 1954. 12 pp) AERE NP/R 1594 2s 6d*

The analysis of thorium-cerium binary alloys. *G. W. C. Milner, G. W. Sneddon.* (Sept 1955. 17 pp) AERE C/R 1740 3s 6d*

The temperature distribution in a heated clay block and its application to the problem of fission product disposal. *C. B. Amphlett, D. T. Warren.* (Feb 1956. 9 pp) AERE C/R 1861 1s 9d*

The spectrographic determination of Mo, Be, Fe, Cr and Ni in bismuth and bismuth-uranium alloys. *M. J. Owers, M. S. W. Webb.* (Dec 19, 1956. 17 pp) AERE C/R 2115 2s 9d*

Development of a remotely operated vacuum induction furnace. *G. M. Gillies, B. A. J. Lister.* (July 1957. 17 pp) AERE C/R 2148

Experience obtained on a liquid sodium heat transfer rig 1954/56. *E. C. Firman, R. I. Hawes, D. W. G. Sturge.* (Aug 1957. 42 pp) AERE R/R 2190

The preparation of uranium trioxide by thermal decomposition of uranyl nitrate. *B. A. J. Lister, R. J. Richardson.* (Oct 18, 1954. 15 pp) AERE C/R 2276 2s 6d

Some pile oscillator cross-section measurements made in the Dimple thermal pit. *J. D. Cummins.* (Aug 1957. 24 pp) AERE R/R 2333 3s 6d*

A new approach to two group diffusion calculations for heterogeneous lattices. *M. C. Hartnell-Beavis, D. Hicks.* (Aug 1957. 46 pp) AERE R/R 2346 7s*

The control of mercury metal in the laboratory. *R. O. R. Brooks, A. Holmes.* (July 1957. 21 pp) AERE MED/R 2350 3s*

Radiostrontium in soil, grass, milk and bone in the United Kingdom: 1956 results. *F. J. Bryant et al.* (Aug 1957. 31 pp) AERE HP/R 2353 5s*

The (n,2n) cross-section of Th 232 for fission neutrons. *J. A. Phillips.* (Aug 1957. 17 pp) AERE R/R 2366 3s*

Gamma spectroscopy applied to radioactivation analysis. Part 3. The determination of cobalt in iron using gamma-gamma coincidence measurement. *L. Salmon.* (Sept 1957. 17 pp) AERE C/R 2377(3)

Nuclear data series. *J. S. Story.* Part 1. (April 1953. 28 pp) AERE T/R 2389 4s*

Oxidation potential of the Pu III-Pu IV couple in 8M ammonium nitrate-0·5N nitric acid solution. *J. L. Bunce, J. D. Nye.* (Aug 1950. 9 pp) AERE C/R 2410 1s 9d*

An electronic fluxometer. *G. F. Snelling, I. A. D. Lewis.* (May 1952. 9 pp) AERE G/M 131 1s 9d*

The 1441A oxygen leak detector. *R. S. Barton.* (Jan 1956. 13 pp) AERE GP/M 189 2s 6d*

Calculations of the filtration of airborne dust by fibrous filters. *R. F. Hounam, J. E. Wilkins.* (Nov 1952) AERE HP/M 43 3s*

A palladium column for concentrating tritium from 2-litre mixtures of tritium and hydrogen. *J. Chadwick.* (Oct 1957. 6 pp) AERE I/M 47 1s 9d*

The neutron spectrum, thermal utilisation and conversion factor in LMFR. *W. G. Davey.* (Oct 1956. 13 pp) AERE R/M 97 2s 3d*

The build-up of uranium isotopes by irradiation of U-233. *W. G. Davey.* (Oct 1956. 10 pp) AERE R/M 98 1s 9d*

The commissioning and operation of a small bismuth loop and tests on a d.c. electromagnetic pump. *E. H. Aldworth.* (Oct 1957. 14 pp) AERE R/M 148 3s*

A multigroup diffusion theory programme for plane slab or spherical systems. *P. D. Preston, M. E. Mandl.* (Jan 1958. 16 pp) AERE T/M 154

A selected reading list on thermonuclear reactions. *C. S. Sabel.* (Oct 1957. 4 pp) AERE Inf/Bib 114

Industrial Group

Experiments on a fluid piston bearing. *J. L. Dickson* (Sept 1957. 12 pp) IGR TN/CA 768

Fission product formation and decay characteristics: information bibliography. (Dec 1957. 10 pp) IGRL IB/R 29

Some recent developments in automatic control: information bibliography. *A. F. Armstrong, G. I. Maughan.* (Oct 1957. 40 pp) IGRL IB/R 33

The disposal of radioactive waste to the sea during 1956. *H. J. Dunster.* (Jan 1958. 3 pp) IGS R/R 2

A summary of the biological investigations of the discharge of aqueous radioactive waste to the sea from Windscale Works. Sellafield, Cumberland. *H. J. Dunster, F. R. Farmer.* (Jan 1958. 12 pp) IGS R/R 3

United States

The following reports can be obtained from the Office of Technical Services, US Department of Commerce, Washington 25, DC, at the prices stated.

Heat transfer from rods normal to subcooled water flow for non-boiling and surface-boiling conditions up to and including burnout. (Jan 1958. 146 pp) ANL 5822 $4

Hydraulic flow calculations for MTR-ETR experiments standard practices manual. (Nov 1957. 69 pp) IDO 16368 $2

Reactor development quarterly progress report, 4000 program. (Oct 1955. 50 pp) ANL 5514 $1.25

Power transfer functions of the EBWR obtained using a sinusoidal reactivity driving function. (Jan 1958. 50 pp) ANL 5798 $1.50

Power reactor studies quarterly progress report, May, June and July 1957. (Sept 1957. 66 pp) DP 245 $1.75

A UO_2-bismuth system as a reactor fuel. (July 1957. 21 pp) KAPL 1877 75c.

The experimental development of a fuel handling system for the sodium reactor experiment. (Jan 1958. 48 pp) NAA/SR 2004 $1.50

Homogeneous reactor project quarterly progress report for period ending October 31, 1957. (185 pp) ORNL 2432 $5.50

Reactor and plant engineering. Bettis technical review. (Dec 1957. 146 pp) WAPD/BT 5 $2.75

Pressurized water reactor (PWR) project, technical progress report for the period October 24, 1957, to December 23, 1957 (89 pp) WAPD/MRP 71 $2.50

A square-wave cyclotron oscillator. (52 pp) ORNL 2403 $1.75 The fabrication of fuel subassemblies for the borax-III reactor. (Jan 1958. 35 pp) ANL 5559 $1

Development of ultrasonic techniques for inspecting experimental boiling water reactor cast uranium alloy cores and fuel plates. (Dec 1957. 31 pp) ANL 5653 $1

Quarterly report January, February and March 1957, Metallurgy Division, Argonne National Laboratory. (Mar 1957. 67 pp) ANL 5717 $2

Irradiation of uranium-fission alloys and related compositions. (Sept 1957. 55 pp) ANL 5736 $1.50

Tick **No 75** on reply card for further details

Solartron to market Ericsson instruments

The Solartron Electronic Group Limited and Ericsson Telephones Limited

HAVE PLEASURE IN ANNOUNCING

that as from the 1st March, 1958, they have concluded arrangements for Solartron to market, throughout the world, the ETL range of electronic and nucleonic instruments and ETL components

Enquiries for these should therefore be directed to:

THE SOLARTRON ELECTRONIC GROUP LIMITED

THAMES DITTON, SURREY, ENGLAND

Telephone: Emberbrook 5522 · Cables: Solartron, Thames Ditton

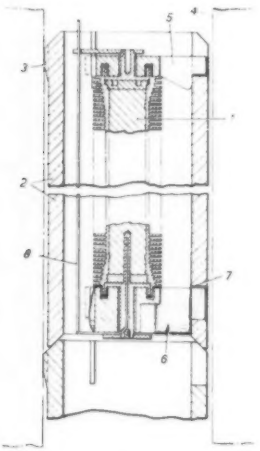
SOLARTRON

T E L ENGLAND

PATENTS

Replaceable channel fuel elements

A unique feature of the GEC Hunterston power station is the use of what the firm call the 'replaceable channel fuel element' and the patent covers the idea. The actual metallic element is generally similar to those used in other power stations—a uranium bar sheathed in a helically-finned can—but it is supported inside a sleeve of graphite or other material. The composite elements are stacked inside channels through the core and are charged and discharged as complete units. The advantages claimed are: 1. the core channels are protected against mechanical abrasion during fuelling operations, 2. the moderator is protected against chemical attack and mass transfer from the coolant, 3. if there is a burst slug it is only the sleeve which



791,011 HUNTERSTON SLEEVES
1 Fuel element
2 Sleeve (graphite)
3 Radial lugs
4 Core channel
5 Top spider (carbon)
6 Bottom spider (carbon)
7 Spider slot
8 Thermocouple lead

is contaminated. The sleeve also takes all the weight, thus elements are uniformly stressed.

Working on this idea, the specification covers several variants, including the use of plate-type elements.

791,011 Improvements in or relating to nuclear reactors *General Electric Co Ltd* (Inventors: W. E. Dennis and P. A. Lindley) Appn: July 27, 1955 Pubd: Feb 19, 1958

Using medium-energy neutrons

In power reactors the formation of Pu-239 on a large scale is often undesirable. Also as the capture cross-section of uranium for medium-fast neutrons is greater than for thermal ones, neutron losses occur at the fuel element surface. To overcome these disadvantages the inventors propose coating the uranium with thorium. Th-232 also has a very large absorption cross-section for medium-fast neutrons, but decays to U-233 which has a higher neutron yield than Pu-239, even with slow neutrons. The reactivity of the whole element may be maintained constant by preferential and controlled formation of U-233 or may even be increased during operation as required. The element may take any of a number of shapes and it not limited to using metallic uranium and thorium.

792,170 Fuel element for nuclear reactors *Physikalische Studiengesellschaft Düsseldorf mbH* Appn: Nov 7, 1955 Pubd: March 19, 1958

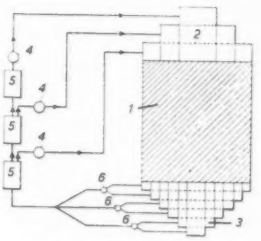
Reducing can stretch

This is a modified Calder type fuel element, designed to reduce cumulative stretching of the can. On heating, the can expands longitudinally more than the fuel element and on cooling, friction prevents the free contraction of the can. Repeated thermal cycling increases the stretch cumulatively, results finally in fracture. To prevent this, a series of grooves are machined in the element—thirteen in all—and the can driven into them by pressurization. This is achieved by placing the sealed element in a pressure vessel filled with dry CO_2 at 100 psi and heated uniformly to 500°C over a period of three hours. This causes a pressure rise to 350 psi, maintained for four hours, and controlled cooling then takes place over a further three hours.

790,389 Improvements in or relating to fuel elements for use in nuclear reactors *United Kingdom Atomic Energy Authority* Appn: Oct 14, 1955 Pubd: Feb 5, 1958

Zoned cooling

In a gas-cooled reactor the heat output is proportional to the neutron flux and is therefore highest near the centre of the core, decreasing radially outwards to the periphery. Higher rated channels are limited by the maximum temperature in the uranium and in peripheral channels the limit is set by the maximum permissible can temperature. In an intermediate zone both factors have to be taken into account. Thus, say these inventors, there is an optimum thermodynamic condition for each channel and to obtain this they propose dividing the channels into annular groups. In a particular application—which seems to be similar to the arrangement used in the Marcoule reactors—there are three annular inlet zones supplied from concentric manifolds. Temperatures are 50, 150 and 200°C reading radially outwards. Inlet pressure is the same in each (200 psi).



792,171 MARCOULE CONCENTRICS
1 Core
2 Inlet zones
3 Outlet zones
4 Circulators
5 Heat exchangers
6 Jet pumps

On the outlet side there are two annular manifolds to each inlet one and the flows are mixed by jet pumps. The illustration shows three separate heat exchangers but the invention includes the use of one unit provided with three outlets. Incidentally, the inventors point out that a canning material with a higher maximum permissible temperature than uranium would obviate the necessity for these measures. Compared with the method of gagging the outer channels the inventors claim that this system gives a notable increase in thermodynamic efficiency.

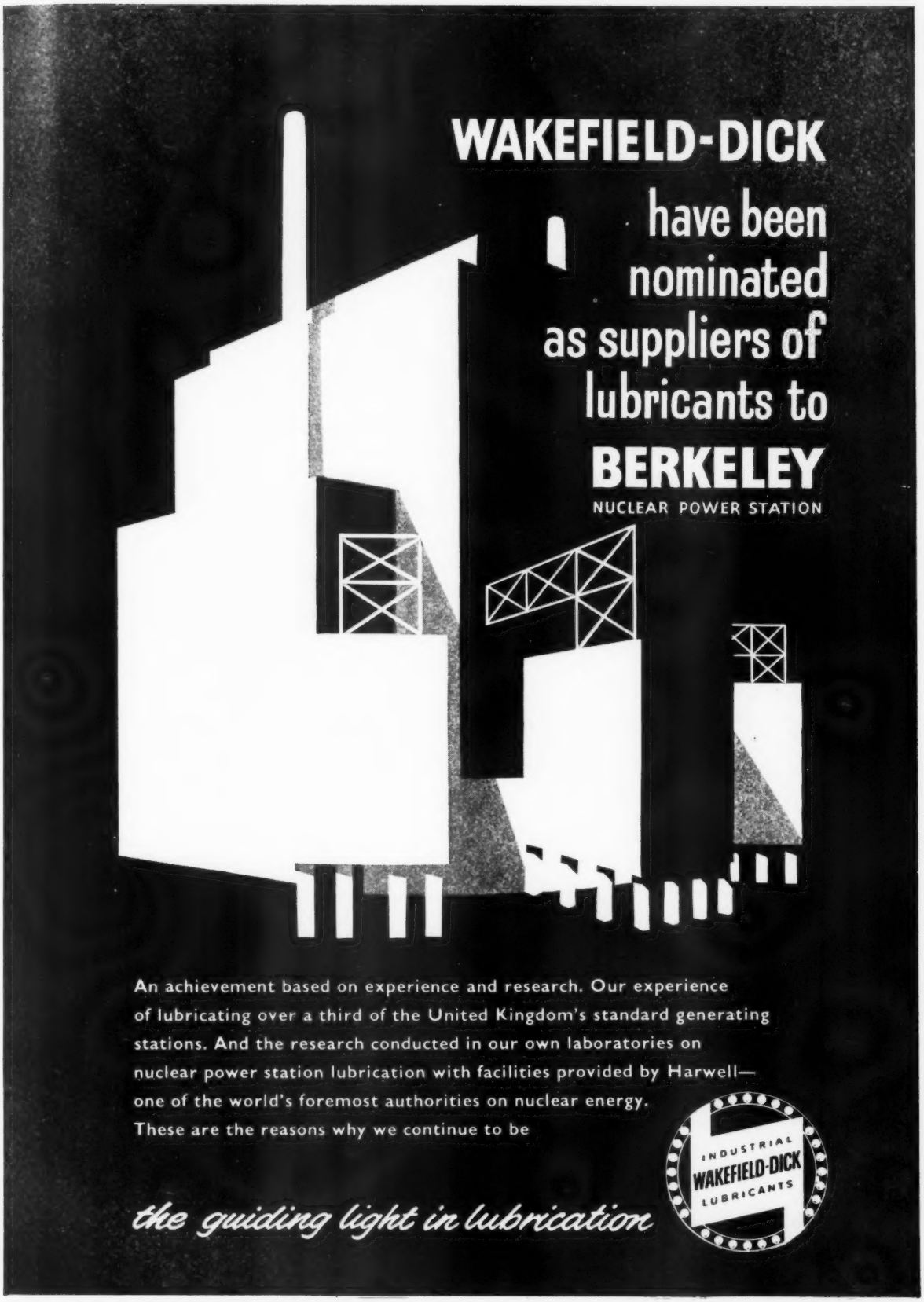
792,171 Improvements in or relating to nuclear reactors *Commissariat à l'Energie Atomique* (Inventors: J. le Foll and G. Melese) Appn: Nov 8, 1955 Pubd: March 19, 1958

Niobium-coated fuel

So that fuel cans can be made of metals which form compounds or alloys with the fuel element at temperatures below 800°C, it is proposed to coat the element with a thin layer of niobium. This gives adequate heat transfer and avoids metallic interaction. The layer is formed either on the element itself or on the can by electrodeposition, decomposition of a niobium compound vapour, by metal spraying etc. Alternatively niobium foil can be wrapped round the element. Suitable layer thickness is 1 to 2 mils. After assembly and sealing, the can is subjected to pressure as usual to ensure can/niobium and niobium/element contact.

790,334 Improvement in or relating to the canning of metals *United Kingdom Atomic Energy Authority* Appn: Nov 18, 1955 Pubd: Feb 5, 1958

These abstracts are made from British Patent Specifications with the permission of the Controller of Her Majesty's Stationery Office. Complete specifications can be obtained from the Patent Office (Sales Branch), 25 Southampton Street, London, W.C.2. 3/6 a copy (including postage, inland and abroad)



WAKEFIELD-DICK

have been nominated as suppliers of lubricants to

BERKELEY

NUCLEAR POWER STATION

An achievement based on experience and research. Our experience of lubricating over a third of the United Kingdom's standard generating stations. And the research conducted in our own laboratories on nuclear power station lubrication with facilities provided by Harwell—one of the world's foremost authorities on nuclear energy. These are the reasons why we continue to be

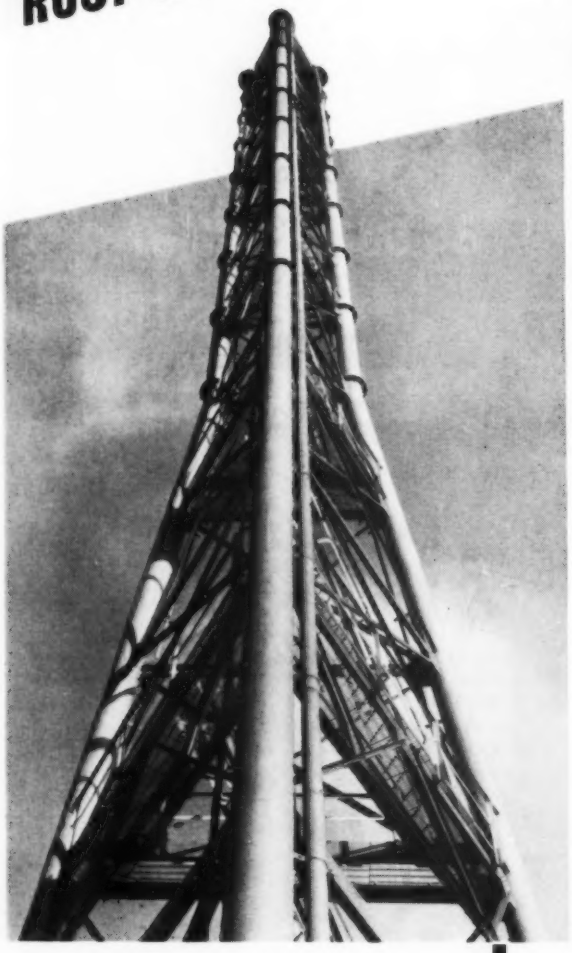
the guiding light in lubrication

INDUSTRIAL WAKEFIELD-DICK LUBRICANTS

WAKEFIELD-DICK INDUSTRIAL OILS LTD

Tick **No 77** on reply card for further details

PROTECTED AGAINST RUST WITH RUST-ANODE



One of our many jobs recently completed in South Wales, and throughout the world. Blast Furnace Bleeder, Morgam, South Wales, protected by Rust Anode throughout. Leading authorities specify Rust Anode Cold Galvanizing to ensure the complete protection of all steel structures. There is no substitute. Capalla Rust Remover and inhibitor. Our world wide service is at your disposal. Write or phone for brochure, B.S. No. 1391 Test Certificate.

C. & P. DEVELOPMENT Co. (London) Ltd.
CORROSION SPECIALISTS
WIGGIE WORKS, REDHILL, SURREY
and 88, GREENLEA ROAD, TERENURE, DUBLIN
Telephone: REDHILL 4554

CAP PRODUCT

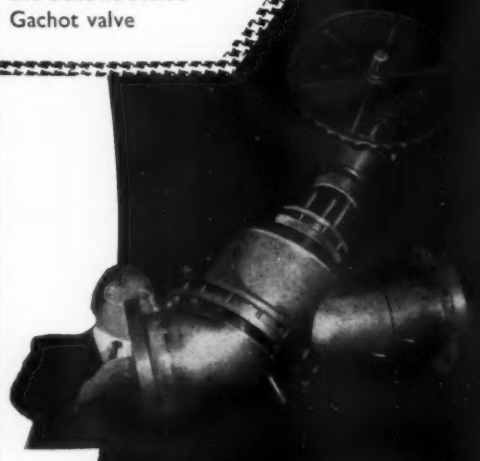
Tick **No 78** on reply card for further details

TECHNIQUES NUCLÉAIRES

DESIGN AND MANUFACTURE

DESIGN AND MANUFACTURE
IN THE ATOMIC FIELD

A new development:
the bellows-sealed
Gachot valve



- All stainless steel Argon-Arc welded
- Vacuum leak checked
- Tested with helium leak detector

TN 3 57

This valve is already fitted at :

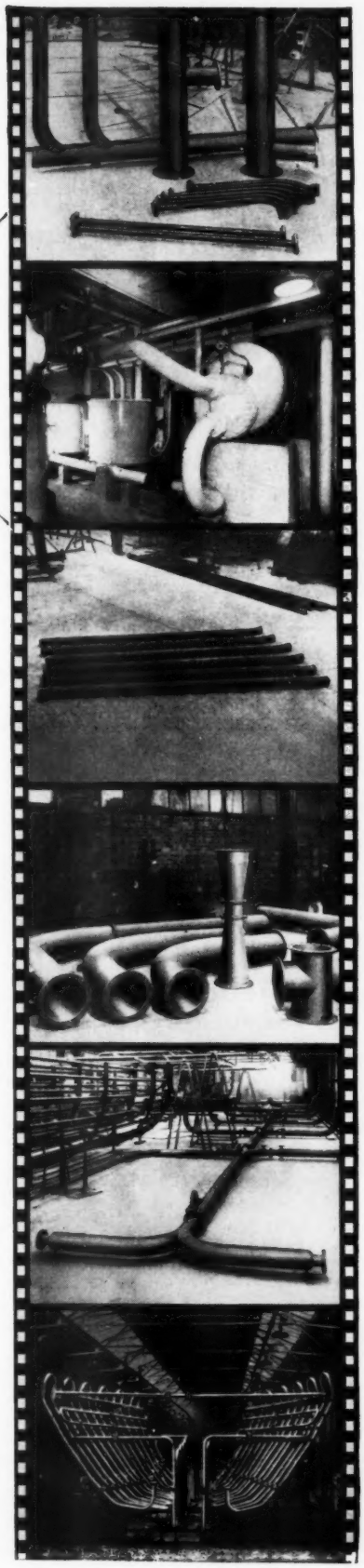
THE RESEARCH REACTORS EL3, P2, Aquilon AT SACLAY

THE LIQUID METAL SYSTEMS AT CHATILLON

THE PLUTONIUM PLANT AT MARCOULE

TECHNIQUES NUCLÉAIRES Co. Ltd.

82, rue Montigny, ARGENTEUIL (S.-et-O.) FRANCE



and the Industrial Scene

Fabricated pipeworks by Steels Engineering Installations are leaving our Crown Works for all parts of the world. Pipe layouts are prepared with complete accuracy from site measurement and drawing details to facilitate rapid erection. Valuable service is being rendered in the marine, chemical and oil industries, great nationalised industries, and atomic energy projects.

Steels offer a wealth of specialised experience to every type of pipe fabrication, will advise upon the metallurgical suitability of materials and all design facilities are available. A well-equipped laboratory provides facilities for both destructive and non-destructive testing of welds. The manipulation and welding of all types of tube requires a high level of skill and experience and exceptional engineering qualification. Steels Engineering Installations are world renowned for quality and high standards.

Our fabrication methods include all new and established principles of manipulation, welding, flanging and screwing in all the materials normally used in the manufacture of tubes:-

- **Mild Steels; Carbon Molybdenum and Chromium Molybdenum Steels.**
- **Stainless Steels (austenitic and heat resisting).**
- **Cast Iron.**
- **Copper and Copper Alloys.**
- **Aluminium and Aluminium Alloys.**
- **Plastics.**

(*Fabricated to both British and American standards*).

STEELS ENGINEERING INSTALLATIONS LTD

CROWN WORKS, SUNDERLAND STEEL **Tel: Sunderland 56281 (10 lines)**

U.K. & OVERSEAS SALES OFFICE: 143 SLOANE ST., LONDON, S.W.1

Tel: London, SLOane 6178 (5 lines) Grams: Steelascos Knights London.

© 8962

Tick **No 80** on reply card for further details

Welding & Construction

INSPECTION

Many large firms have already appreciated the service inaugurated by Gamma-Rays Ltd. who are an authority approved by the leading Insurance Companies and Service Departments. This authority is entirely independent and unconnected with any welding organisation. As specialists in this particular field, we are able to give a service which guarantees a high standard of welding throughout.

Our Welding Supervision Inspectors control the construction throughout from Analytical & Metallurgical Testing of Pipe ★ Complete Physical Testing ★ Approval of Welders Tong Testing ★ X-Ray & Gamma Photography. Holiday Detector Service also available.

Gamma-Rays LIMITED

FOUNDRY LANE SMETHWICK 40 STAFFS

TELEPHONE SMETHWICK 0846/7 TELEGRAMS GAMMA-RAYS

MAKE LIGHT OF THAT

Heavy Duty

Equip with KING DICK

Precision-made under carefully controlled conditions, KING DICK Hand Tools set a superlative standard for Heavy Engineering work.

Please send for fully illustrated catalogue which will give you complete details of our range of hand tools.

BUY KING DICK BRITISH!

BINGDON **KING DICK** HAND TOOLS

ABINGDON WORKS · TYSELEY
BIRMINGHAM 11 · ENGLAND

HEAVY DUTY RING SPANNERS
A formidable tool when used in conjunction with our special tubular handles.

OPEN-ENDED PODGERS
In B.S., B.S.W., American, A/F and Unified Hex. sizes.

SLOGGING RING SPANNERS
Available in B.S. Whitworth, American, A/F and Unified Hex. Sizes to suit all requirements.

FLAT 7½° SLOGGING RING SPANNER
In B.S., B.S.W., American, A/F and Unified Hex. sizes.

PODGER-ENDED SOLID BOX SPANNERS
In B.S., B.S.W., American, A/F and Unified Hex. sizes.

RING PODGER SPANNERS
A heavy duty tool supplied in all sizes to meet your requirements.

OPEN ENDED PODGER SPANNERS (Flat 15°)
Forged in Chrome Vanadium Steel to withstand the hardest work.

POWER OPERATED SOCKETS
For assembly lines, heavy engineering and Hicycle Tools. In ⅜", ½", ¾", 1", 1½", and 2½" Square Drive.

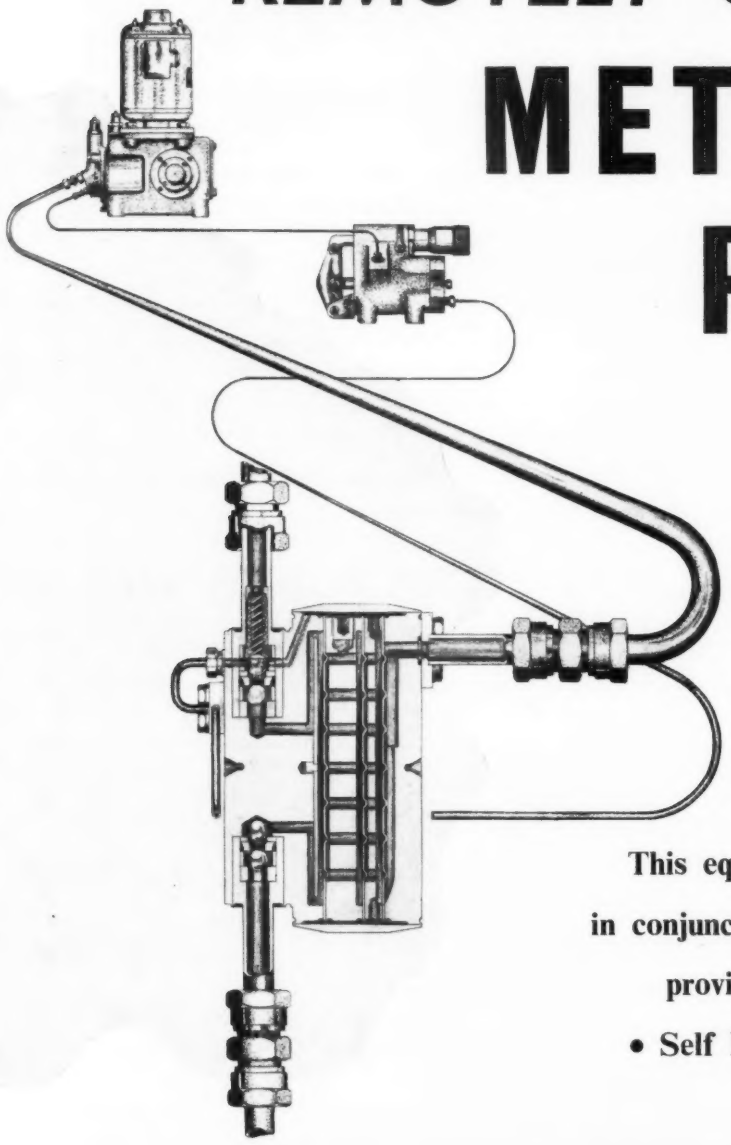
R.E.200/4

Tick **No 81** on reply card for further details

Tick **No 82** on reply card for further details

REMOTELY OPERATED

METERING PUMPS



FOR PUMPING CORROSIVE AND RADIOACTIVE LIQUIDS

This equipment, originally developed in conjunction with A.E.R.E. Harwell, provides for • Accurate Metering • Self Priming • Remote Hydraulic Drive and Control

KONTAK

Manufacturing Company Ltd.

BELTON PARK, LONDON THORPE ROAD, GRANTHAM, LINCS.

Telephone: GRANTHAM 908

Tick **No 83** on reply card for further details

The MAPEL Welding Inspection Service to Industry

MAPEL offer a comprehensive welding inspection service, which incorporates non-destructive examination visually, by radiography and by ultrasonics, to guarantee that the highest standards and specifications are adhered to.

Wherever welding is carried out, whether it be on pipelines, vessels, storage tanks, structural work or shipbuilding, the MAPEL Service will guarantee you high quality workmanship from start to completion. Further information will gladly be supplied on request.

Note: MAPEL also provide a comprehensive Cathodic Protection Service and Leak Detection.

MAPEL

METAL and PIPELINE ENDURANCE LTD

Head Office :

Artillery Mansions, Victoria Street, S.W.1 Telephone : ABBey 6055 Telegrams : Metaldure, Sowest, London

And at Woolmer Green, Newcastle-on-Tyne, and Glasgow. Continental Agencies

MERITUS

Meritus bench type spot welding machine 6 kVA "Autoforge"

RESISTANCE WELDING MACHINES

SERVING

THE

NUCLEAR POWER INDUSTRY

SPOT, STITCH, BUTT & SEAM WELDERS

MODELS FROM 5—60 KVA. Pedal or Air Operated

MERITUS (BARNET) LTD.

BARNET, HERTS. **Telephone: BARNET 2291/2**

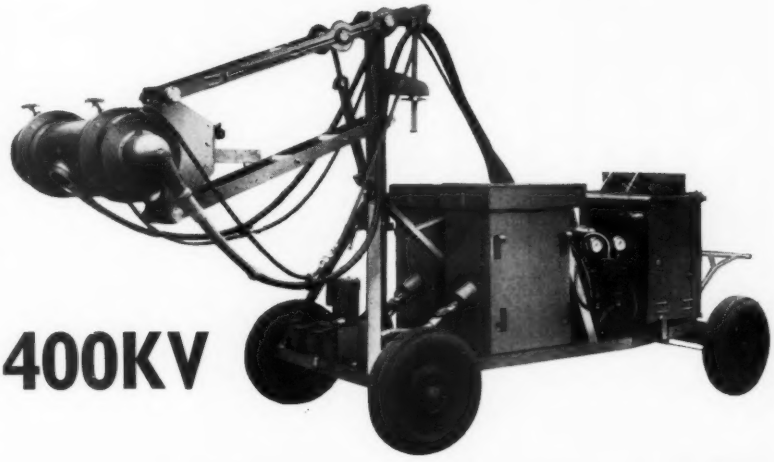
Tick **No 84** on reply card for further details

Tick **No 85** on reply card for further details

INDUSTRIAL X-RAY EQUIPMENT

If you are interested in the radiography of welded seams up to 4" thick, this new equipment will produce first class radiographs with short exposure times. It is rated at 400 KV. and utilises a constant potential circuit with long life metal rectifiers instead of valves.

Our large range of equipment can meet your requirements. Write today for details.



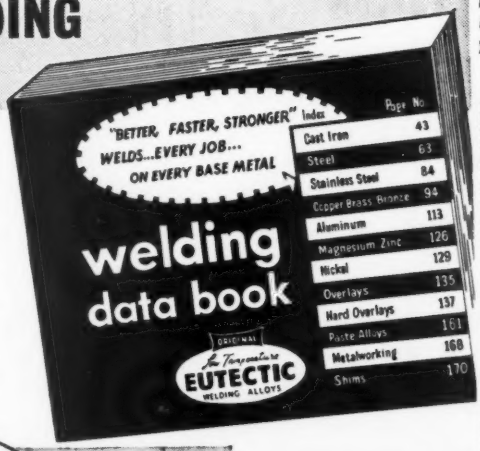
400KV

PANTAK LIMITED

72-76 ALPHA STREET, SLOUGH, BUCKS. Telephone: SLOUGH 21129

FREE for welders, welding users, purchasing agents

180 PAGE WELDING DATA BOOK



A COMPLETE POCKET-SIZE REFERENCE GUIDE

includes: CHOOSING THE RIGHT ROD FOR THE RIGHT JOB · 150 DIFFERENT ALLOYS INDEXED AND THOROUGHLY EXPLAINED · TIPS FOR MACHINABLE AND COLOUR MATCHING DEPOSITS RECOMMENDED AMPERAGES · TORCH SETTINGS AND ELECTRODE TECHNIQUES FULLY ILLUSTRATED · NEW WAYS TO CUT DOWN ON WELD METAL.

Here is the completely revised "Eutectic" Welding Data Book for 1958. Thousands of welding users keep this handy book within easy reach — every page is crammed with practical, valuable information—so much so that many call it the welder's 'Bible.' And it's yours free . . . from 'Eutectic.'

REGISTRATION FORM FOR FREE LITERATURE

EUTECTIC WELDING ALLOYS CO. LTD.
NORTH FELTHAM TRADING ESTATE
FELTHAM, Middlesex.

Please send my free copy of 180-page "Eutectic" Welding Data Book.

NAME .....

TITLE .....

ADDRESS .....

N.P.1

BLOCK 'C' BRITISH INDUSTRIES PAVILION BRUSSELS UNIVERSAL EXHIBITION

EUTECTIC WELDING ALLOYS CO. LTD.

NORTH FELTHAM TRADING ESTATE, FELTHAM, MDDX. *Telephone FELtham 6571*

Tick **No 86** on reply card for further details

A79

Tick **No 87** on reply card for further details

Stockholders
OF

STAINLESS STEEL

SHEETS · BARS · TUBES
STRIPS & BLANKS · also
PROFILE CUTTING &
SHEET POLISHING

WE WILL PROFILE ANY SHAPE

C D

COX AND DANKS

LIMITED

SCAPA HOUSE · PARK ROYAL RD.
LONDON N.W.10

A80

Tick **No 88** on reply card for further details

THROUGHOUT THE YEARS

PRECISION ENGINEERS

IN EVERY NEW DEVELOPMENT

DESIGN

TOOLING

PROTOTYPES

SMALL BATCHES

SPECIAL MACHINES

COMPLETE ASSEMBLIES

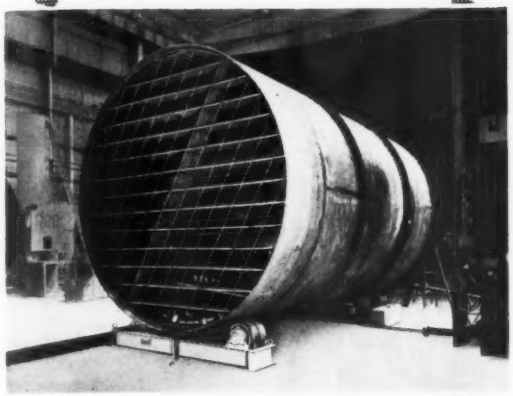
KINGSTON INSTRUMENT GROUP

THE KINGSTON INSTRUMENT CO. LTD.
COX LANE, CHESSINGTON,
SURREY. LOWER HOOK 1001

GLENDAW ENGINEERING CO. LTD.
ST. JAMES ROAD, SURBITON,
SURREY. ELMBRIDGE 0066

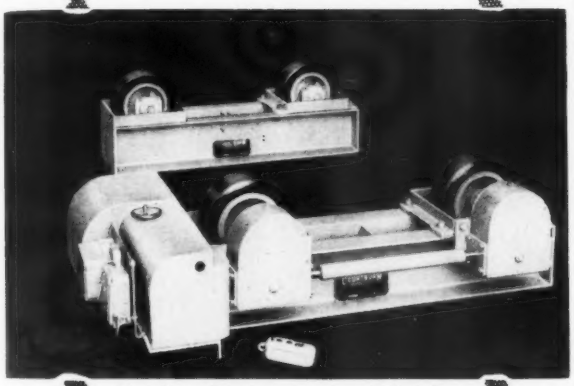
DOWNHAM ENGINEERING CO. LTD.
PRIORY ROAD, DOWNHAM MARKET,
NORFOLK. DOWNHAM MKT 2181

Illustrated is a set of 20 ton Rotators in use by Hughes and Lancaster Ltd., North Wales. All diameter cylinders from 2ft. to 15ft. can be accommodated by a simple and speedy means of adjustment of the roller brackets, which is exclusive to Courtburn Equipment. A wide range of welding speeds is provided by a hydraulic variable speed gear unit.



COURTBURN
POSITIONERS LIMITED

WORK HANDLING EQUIPMENT FOR WELDING



Courtburn Rotators are essential for the smooth efficient and economic welding of all cylindrical vessels. Remote controls with 'stop', 'forward', and 'reverse' are standard equipment, and speed indicators are available.

Rotator sets are made in sizes of 2 tons to 200 tons capacity.

Write for a complete catalogue to:

COURTBURN POSITIONERS LIMITED

KEMPSTON HARDWICK, BEDFORD

Telephone: Kempston 2341/2

From Drawing Board to Site

A. C. WILSON & PARTNERS LTD.

A COMPLETE NUCLEAR ENGINEERING SERVICE

Our unique experience as Nuclear Pioneers, coupled with extensive resources, enables us to undertake

THE DEVELOPMENT, DESIGN AND SUPPLY OF COMPLETE PLANTS

Our services provide for:—

★ Design ★ Tender ★ Progressing
★ Inspection ★ Testing ★ Supply
★ Site Supervision

We have been entrusted with the following:—

- *Underwater Fuel Element Treatment Plant for Dounreay.*
- *Building and Equipment—Experimental Reactor Loops—Dounreay Materials Testing Reactor.*
- *Building and Equipment for Irradiated Fuel Element Laboratory—Windscale.*
- *Services, Plant and Equipment for Cave—Fast Reactor Chemical Separation Plant—Dounreay.*
- *Fuel Element Heat Treatment—Springfields.*
- *Plant and Equipment for Highly Active Solid Waste Disposal—Dounreay.*
- *Experimental Reactor Test Rigs—Harwell.*

We shall be pleased to tender for Nuclear Equipment including:—

Heavy Power Manipulators, Uranium Processing Machines, Remote Handling Equipment, Dry Boxes, etc., etc.

NUCLEAR — MECHANICAL — CHEMICAL — CIVIL — STRUCTURAL & ELECTRICAL ENGINEERS

Design House, The Mall, Ealing, W.5

Telephone - - - - - Ealing 9843 and 1942

Tick **No 91** on reply card for further details

MAGNESIUM ELEKTRON LIMITED

manufacturers of **Uranium Canning Materials**

Magnesium Alloys

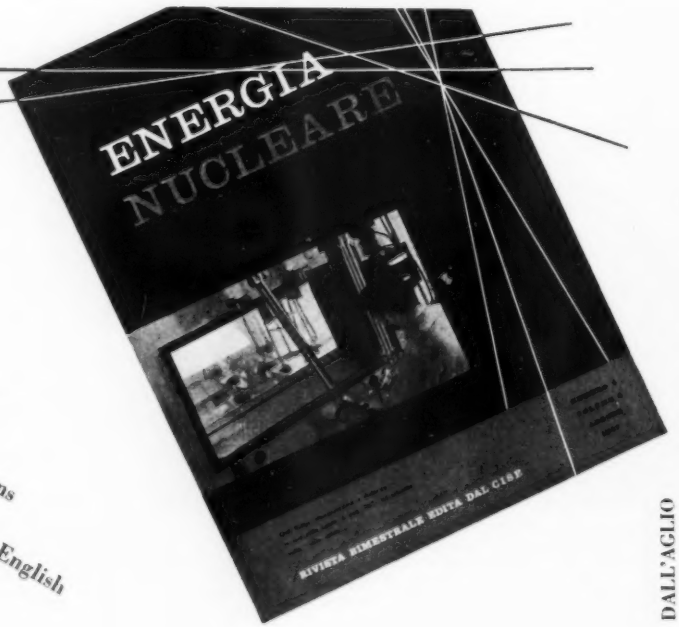
Vanadium Sponge

Low-Hafnium Zirconium Compounds

MAGNESIUM ELEKTRON LIMITED WORKS: Clifton Junction Manchester
LONDON OFFICE: 5 Charles II Street St. James's SW1
Magnesium Elektron, Inc., New York 20, USA

MEL

Publishers: CISE
Centro Informazioni
Studi Esperienze
Milano, via Serbelloni 1



DALL'AGLIO

ENERGIA NUCLEARE
is the Italian magazine dealing with the theoretical and practical problems in the atomic energy field.
Original research papers are published in English.
Subscription rate for 1958:
12 issues Lit. 6000 (£3.10.0)

Sole Agents for Great Britain:

Subscriptions: Nuclear Power, Rowse Muir Publications Ltd. 3 Percy St., London, W1

Advertising: Butlers' Advertising Service Ltd. 22 St. Giles High St., London, WC2

Tick **No 92** on reply card for further details

Nuclear Power THE JOURNAL OF BRITISH NUCLEAR ENGINEERING **free enquiry service for . . .**

TECHNICAL LITERATURE

To help you keep right up to date in design, planning or actual buying, NUCLEAR POWER has compiled this list of advertised products and services under broad group headings. Study the advertisements and then simply tick the items about which you would like further details. Then post this form back to us and we will take immediate action to see you receive the information you want.

Cables
- ☐ Aluminium Wire & Cable Co Ltd A36
- ☐ Wandleside Cable Works Ltd A8

Capital equipment
- ☐ Armstrong Whitworth Aircraft Ltd Sir W. G. A92
- ☐ Fielding & Platt Ltd A21

Carbon and graphite
- ☐ Acheson Colloids Ltd A63
- ☐ Graviner Mfg Co Ltd A24

Construction and allied services
- ☐ Butters Bros Ltd A72
- ☐ Sankey Sheldon, Unistrut Division A54
- ☐ Steels Engineering Products Ltd A39
- ☐ Wharton Crane & Hoist Co Ltd, The A10

Corrosion prevention
- ☐ Bitulac Ltd A86
- ☐ British Paints Ltd A23
- ☐ Detel Products Ltd A67
- ☐ C & P Development Co (London) Ltd A74

Design and allied services
- ☐ Dargue Bros Ltd A93
- ☐ Screw Machine Products Ltd A104
- ☐ Wilson & Parners, A. C. A81

Electrical generating and subsidiary equipment
- ☐ Bailey & Co Ltd, N. G. A53
- ☐ Central Electricity Generating Board A43
- ☐ Electrical Power Engineering Co (Birmingham) Ltd A83
- ☐ Electropower Gears Ltd A89
- ☐ Erhard, Johannes A22
- ☐ Holman Bros Ltd Cover 4
- ☐ Lincoln Electric Co Ltd A55
- ☐ Lyons Ltd, Claude A87
- ☐ Metropolitan-Vickers Electrical Co Ltd A27

Fabrication and machining
- ☐ Aero Precisions Ltd A47
- ☐ Armstrong Whitworth Aircraft Ltd, Sir W. G. A92
- ☐ Booth & Co Ltd, James A99
- ☐ Firth-Derihon Stampings Ltd, The A11
- ☐ Kingston Instrument Group A80
- ☐ Lake & Elliot Ltd A93
- ☐ Marston Excelsior Ltd A6
- ☐ Ross, Donald and Partners A40
- ☐ Scottish Machine Tool Corp. Ltd A45
- ☐ Skinningrove Iron Co Ltd A58
- ☐ Watson Ltd, Robert A20
- ☐ Yorkshire Engineering & Welding Co (Bradford) Ltd A90

Filters
- ☐ Aerox Ltd A94
- ☐ Amal Ltd A98
- ☐ Doulton Industrial Porcelains Ltd A104
- ☐ Heather Filters Ltd A91
- ☐ Intermit Ltd A32
- ☐ Mancuna Engineering Ltd A30
- ☐ Vokes Ltd A33

Fire extinguishing equipment
- ☐ Nu-Swift Ltd 247
- ☐ Pyrene Co Ltd, The A18

Gas treatment, movement, control and storage
- ☐ Amal Ltd A98
- ☐ British LaBour Pump Co Ltd A13
- ☐ Erhard, Johannes A22
- ☐ Howden & Co Ltd, James Cover 2
- ☐ Keith, Blackman Ltd A16
- ☐ Lee, Howl & Co Ltd A102
- ☐ Madan & Co Ltd, Charles S. A91
- ☐ Williams & James (Engineering) Ltd A92

Heating plant and equipment
- ☐ Isopad Ltd A56
- ☐ Mancunia Engineering Ltd A30
- ☐ Stabilag Co Ltd, The A95

Industrial films, books and exhibitions
- ☐ Dendy & Associates Ltd, Richard (Models) A103
- ☐ Energia Nucleare A82
- ☐ Institute of Welding, The 241
- ☐ Turners Film Productions A85

Instrumentation
- ☐ Ayling Nuclear Equipment Co A59
- ☐ Burndept Ltd A88
- ☐ Fielden Electronics Ltd A61
- ☐ Integral Ltd A100
- ☐ Kent Ltd, George Cover 3
- ☐ Nash & Thompson Ltd A88
- ☐ Pascall Engineering Co Ltd A100
- ☐ Philips Electrical Ltd Cover 1
- ☐ Solartron Electronic Group Ltd 253
- ☐ Stanton Instruments Ltd A87
- ☐ Stephen & Co Ltd, R. A. A96
- ☐ Vokes Ltd A33

Instrumentation components
- ☐ Evershed & Vignoles Ltd A29
- ☐ Imhof Ltd, Alfred A42
- ☐ Lyons Ltd, Claude A87
- ☐ Klaxon Ltd A95
- ☐ Mullard Ltd X-ray Division A28
- ☐ Nash & Thompson Ltd A88
- ☐ Nuclear Enterprises (GB) Ltd A84
- ☐ Simmonds Ltd, L. E. A102
- ☐ Texas Instruments Ltd A64

Insulation
- ☐ Cape Asbestos Co Ltd, The A14
- ☐ Darlington Insulation Co Ltd, The A62
- ☐ Delaney Gallay Ltd 245
- ☐ Isopad Ltd A56
- ☐ Moler Products Ltd A65
- ☐ Newalls Insulation Co Ltd A2
- ☐ Versil Ltd A34-A35

Liquid treatment, movement, control and storage
- ☐ Amal Ltd A98
- ☐ Bailey & Co Ltd, Sir W. H. A97
- ☐ Butterfield Ltd, W. P. A52
- ☐ Boby & Co Ltd, William A83
- ☐ Boving & Co Ltd A46
- ☐ Erhard, Johannes A22
- ☐ Evans & Sons (Wolverhampton) Ltd, Joseph A97
- ☐ Flight Refuelling Ltd 251
- ☐ Howden & Co Ltd, James Cover 2
- ☐ Kontak Mfg Co Ltd A77
- ☐ Lee, Howl & Co Ltd A102
- ☐ Madan & Co Ltd, Charles S. A91
- ☐ Palatine Tool & Engineering Co (Surbiton) Ltd A84
- ☐ Stabilag Co Ltd, The A95
- ☐ Worthington-Simpson Ltd A49

Lubricants
- ☐ Shell Mex & BP Ltd 249
- ☐ Wakefield-Dick Industrials Oils Ltd A73

Mechanical handling and positioning
- ☐ Courtburn Positioners Ltd A80

Metals
- ☐ Birmetals Ltd A26
- ☐ Cox & Danks Ltd A80
- ☐ General Electric Co Ltd, The A17
- ☐ Jessop & Sons Ltd, William A4
- ☐ Lake & Elliot Ltd A93
- ☐ Magnesium Elektron Ltd A82
- ☐ Mulberry Co Ltd, The A103
- ☐ Willan Ltd, G. L. A7

Metal treatment
- ☐ Gem Brushes (Luson) Ltd A89

Office equipment
- ☐ Edison Ltd, Thomas A. A94

Power station equipment
- ☐ Head Wrightson Processes Ltd A5
- ☐ Hopkinsons Ltd A19
- ☐ Mirrlees, Bickerton & Day Ltd A15

Reactor construction
- ☐ AEI-John Thompson Nuclear Energy Co Ltd A31
- ☐ General Electric Co Ltd A17
- ☐ Head Wrightson Processes Ltd A5
- ☐ Metropolitan-Vickers Electrical Co Ltd A27
- ☐ Nuclear Power Plant Co, The A51

Reactor equipment
- ☐ Ayling Nuclear Equipment Co A59
- ☐ Bloctube Controls Ltd A102
- ☐ Flight Refuelling Ltd 251
- ☐ Graviner Mfg Co Ltd A24
- ☐ Hopkinsons Ltd A19
- ☐ Kontak Mfg Co Ltd A77
- ☐ Marston Excelsior Ltd A6
- ☐ Techniques Nucléaires Co Ltd A74
- ☐ Unit Superheater & Pipe Co Ltd A101

Remote handling equipment
- ☐ General Electric Co Ltd A17
- ☐ Savage & Parsons Ltd A68
- ☐ Wilson & Partners, A. C. A81

Shielding
- ☐ General Electric Co Ltd, The A17
- ☐ Grey & Marten Ltd A69
- ☐ Jenkinson Ltd, W. G. A86
- ☐ Lead Development Association A104

Special equipment
- ☐ Amal Ltd A98
- ☐ Bailey & Co Ltd, Sir W. H. A97
- ☐ British Industrial Engineering Co Ltd A60
- ☐ Delaney Gallay Ltd 245
- ☐ Downham Engineering Co Ltd A81
- ☐ Engineering Appliances Ltd A37
- ☐ Klaxon Ltd A95
- ☐ Mancuna Engineering Ltd A30
- ☐ Marston Excelsior Ltd A6
- ☐ Matthews & Yates Ltd A50
- ☐ Oxhycarbon Co Ltd A56
- ☐ Pascall Engineering Co Ltd A100
- ☐ Ross, Donald & Partners Ltd A40

Testing equipment—non-destructive
- ☐ Courtburn Positioners Ltd A88
- ☐ Gamma-Rays Ltd A76
- ☐ Metal and Pipeline Endurance Ltd A78
- ☐ Metropolitan-Vickers Electrical Co Ltd A27
- ☐ Pantak Ltd A79
- ☐ Philips Electrical Ltd Cover 1

Tools
- ☐ Abingdon King Dick A76
- ☐ Rawlplug Co Ltd, The A9

Tubes, pipes, couplings, seals
- ☐ Accles and Pollock Ltd A3
- ☐ Cox and Danks Ltd A80
- ☐ Klinger Ltd, Richard A25
- ☐ Lawrie Ltd, J. & T. A90
- ☐ Mollart Engineering Co Ltd, The A85
- ☐ Pipe Fabricators (Stamford) Ltd A100
- ☐ Simplifix Couplings Ltd A98
- ☐ Stainless Steel Profile Cutters Ltd A106
- ☐ Steels Engineering Installations Ltd A75
- ☐ Weston & Co Ltd, Charles A12

Welding and Welding equipment
- ☐ Aero Precisions Ltd A47
- ☐ Anglo-Swedish Electric Welding Co Ltd A96
- ☐ British Oxygen Gases Ltd 243
- ☐ Consolidated Pneumatic Tool Co Ltd A48
- ☐ Courtburn Positioners Ltd A81
- ☐ Delaney Gallay Ltd 245
- ☐ Empyrium Welding & Manufacturing Co Ltd A41
- ☐ Enfield Rolling Mills Ltd A44
- ☐ Eutectic Welding Alloys Co Ltd A79
- ☐ Gem Brushes (Luson) Ltd A89
- ☐ Lincoln Electric Co Ltd A55
- ☐ Meritus (Barnet) Ltd A78
- ☐ Metropolitan-Vickers Electrical Co Ltd A27
- ☐ Murex Welding Processes Ltd A1
- ☐ Norton Grinding Wheel Co Ltd A66
- ☐ Philips Electrical Ltd Cover 1
- ☐ Pipe Fabricators (Stamford) Ltd A100
- ☐ Power Jacks Ltd A100
- ☐ Quasi-Arc Ltd A70
- ☐ Rockweld Ltd A38
- ☐ Ross, Donald and Partners Ltd A40
- ☐ Saturn Industrial Gases Ltd A57
- ☐ Semet & Co Ltd, M. A104
- ☐ Skinningrove Iron Co Ltd A58
- ☐ Stainless Equipment (Metal Finishers) Co Ltd A102
- ☐ Unit Supeheater & Pipe Co Ltd A102
- ☐ Watson Ltd, Robert A20
- ☐ Yorkshire Engineering & Welding Co (Bradford) Ltd A90

please send me further information on the above items which I have ticked/or on the following editorial pages 231-233

NAME **POSITION**

ADDRESS

Note that no stamp is needed in United Kingdom

Tuck in this end

This service is designed to give you advice or fuller information on any subject, or service mentioned in this issue—whether in the editorial text or in an advertisement—free of charge

Fold Here

Postage will be paid by Nuclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

Nuclear Power,
3 Percy Street,
London, W1
England

Fold Here

Fold Here First

Nuclear Power
THE JOURNAL OF BRITISH NUCLEAR ENGINEERING

FREE ENQUIRY SERVICE

and

SUBSCRIPTION SERVICE

Do you see

NUCLEAR POWER

regularly?

Through your not seeing even one monthly issue you may have missed something really important in the constantly changing nuclear picture

You can be sure of receiving Nuclear Power regularly every month by simply completing this coupon

Please enter me as a subscriber to Nuclear Power for one year:

United Kingdom	£2 . 2 . 0	+ 10s postage
Other Countries	£3 . 3 . 0	
USA and Canada	$8.00	+ 50c postage

starting with the.....issue

☐ and invoice me later
☐ subscription enclosed

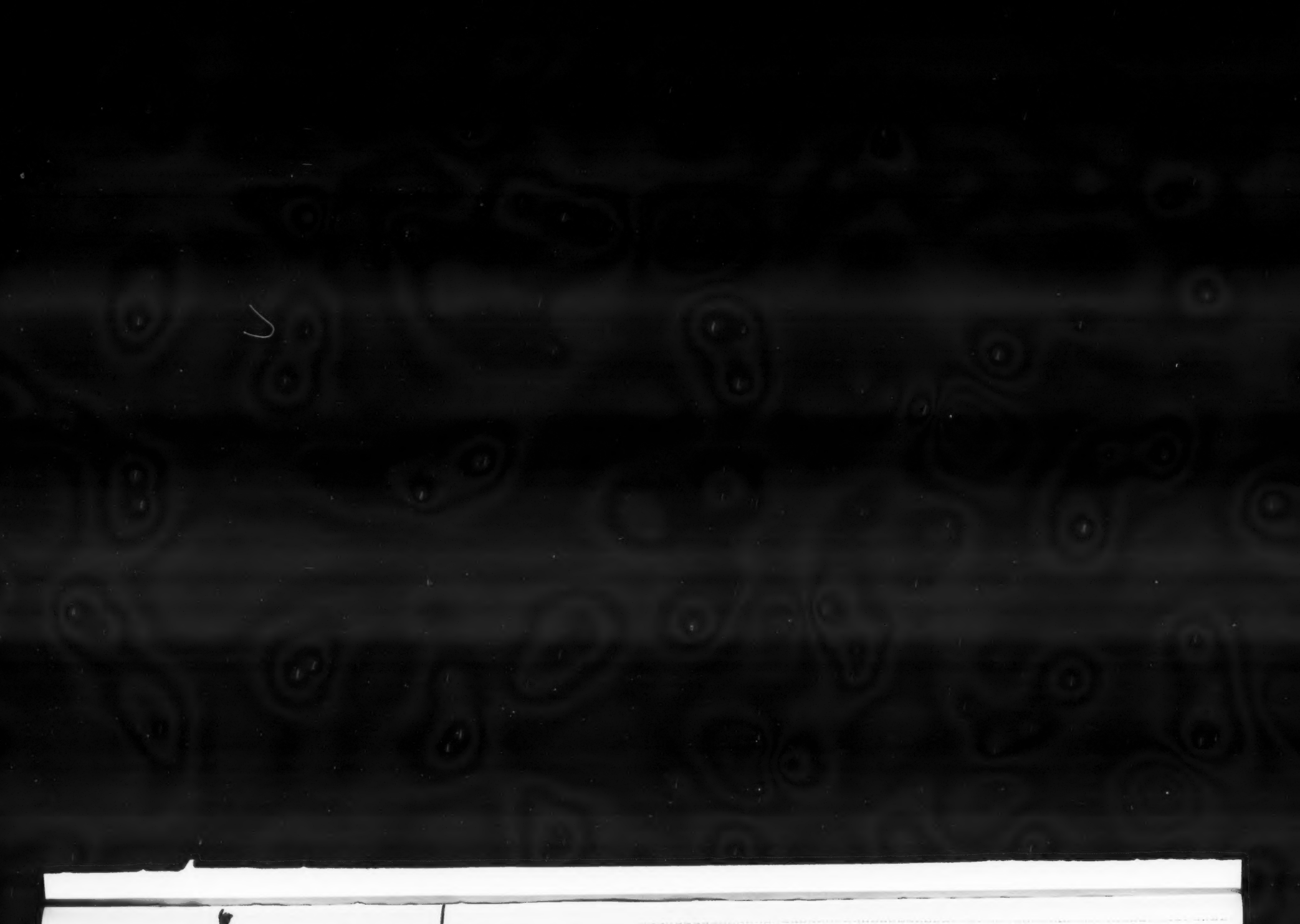
NAME.....

ADDRESS.....

.....

.....

POSITION .....



Tick **No 99** on reply card for further details

'BOBY' Deaerators and Chemical Conditioning Equipment have been installed or are on order for

CALDER HALL
CHAPEL CROSS
BRADWELL

WATER
BOBY
TREATMENT

WILLIAM BOBY & CO. LTD
RICKMANSWORTH, HERTFORDSHIRE, ENGLAND
Telephone: Rickmansworth 4251 *

WHO WANTS

An explosion...

with all its attendant cost and dislocation
Yet it can easily happen.
Better play safe and specify
E.P.E. Flameproof Motors.
Buxton certified of course.

E·P·E

ELECTRICAL POWER ENGINEERING COMPANY (BIRMINGHAM) LIMITED

Bromford Lane, Birmingham, 8. Phone: STEchford 2261. Grams: Torque Phone Birmingham

London Office: 421 Grand Buildings, Trafalgar Sq., London, W.C.2. Phone: Whitehall 5643 & 7963

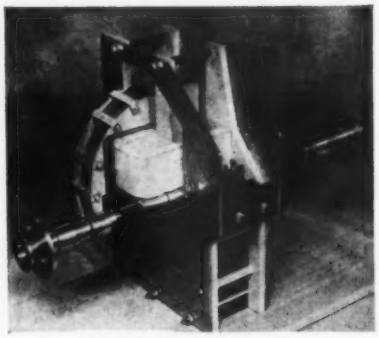
Tick **No 100** on reply card for further details

Tick **No 101** on reply card for further details

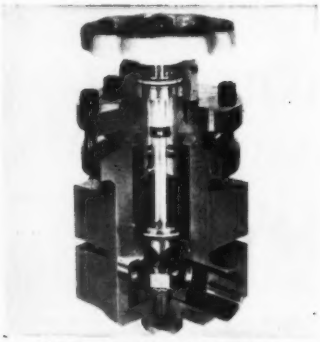
PALATINE

TOOL AND ENGINEERING CO., (SURBITON) LTD. SURBITON, SURREY

Telephone: Elmbridge 7261-2-3



Electro-Magnetic Pump



1" General Purpose Valve

MANUFACTURERS AND DEVELOPMENT ENGINEERS FOR NUCLEAR POWER PROJECTS

Pumps, Hi-Presflex Metallic Flexible Bellows and Valves manufactured for U.K. Atomic Energy Authority

---

Where research counts . . .

PLASTIC LIQUID AND CRYSTAL PHOSPHORS

- PLASTIC PHOSPHOR N.E. 102 light output 65% anthracene available in all shapes and sizes up to one ton or in thin sheet form, in Tubes for the CONSTRUCTION OF SCINTILLATION FLOW COUNTERS or as filaments for the construction of scintillation nuclear track chambers. Bulletin No. 11.
- BORON POLYESTER PLASTIC PHOSPHOR N.E. 400 and N.E. 401 for neutron detection.
- LOADED LIQUID SCINTILLATORS in bulk or encapsulated, containing Pb for extreme X-ray sensitivity, and Gd, B or Cd for neutron detection (bulletins 9 and 9a).
- SCINTILLATING GELS for efficient internal counting of suspended materials (bulletin 9).
- SCINTILLATION CHEMICALS of highest purity P.B.D., POPOP, T.P.B., p-terphenyl, PPO, D.P.H., alpha-N.P.O., vinyl-toluene, styrene, xylene, toluene and methyl borate (bulletin 10).
- HARSHAW SODIUM IODIDE CRYSTALS. Exclusive concessionaire for Great Britain.
- LIGHT PIPES of polyvinyl toluene and polystyrene.

NEW LINE OF *PRECISION* NUCLEAR INSTRUMENTS

- Non Overloading Linear Pulse Amplifier N.E. 5202. of the Fairstein type (Bulletin 14).
- Pre-Amplifier and Cathode follower N.E. 5202 A.
- Single Channel Pulse Height Sorter N.E. 5102.
- Highly stabilised E.H.T supply N.E. 5301.
- Complete assembly for C14 tritium counting, N.E. 8301.
- Shielded Scintillation Head Unit N.E. 5501.
- Complete Human Body Counter Installation N.E. 8101.
- Multi-Channel Scintillation Spectrometer N.E. 8201 for Industrial Tracer Investigations.
- Scintillometer for geophysical exploration.

Nuclear Enterprises (G.B.) Ltd.

BANKHEAD MEDWAY, SIGHTHILL, EDINBURGH, SCOTLAND

Write now for Bulletins 9, 9a, 10, 11, 12, 13, 14 and the 1958 PRICE LIST.

Associate Company: Nuclear Enterprises Limited, 1750 Pembina Highway, Winnipeg, Canada

Telephone: CRA 4513

Tick **No 102** on reply card for further details

Tick No 103 on reply card for further details

angular motion faithfully transmitted

Light Series Universal Joints are available in special designs for aircraft use, made in light alloy to Spec. L.40 anodised, with hardened ground steel trunnion pins, cadmium plated. They are designed with shank diameters to suit bore of standard aircraft tube and will withstand moderate tension or compression loads. Made in a wide range of sizes, they can be supplied with covers as required.

Patent Universal ball Joint combines high load capacity, simplicity of design and 92-98% efficiency. (N.P.L. certified.)

Hooke's Type Universal joint is suitable for high speeds and is inexpensive to fit.

Grease Retaining Covers are available for all types and sizes of joints.

Air Ministry Gauge Test House Authority 89755/31

THE MOLLART ENGINEERING CO. LTD.
KINGSTON BY-PASS · SURBITON · SURREY · ENGLAND
TELEPHONE: ELMBRIDGE 0033-7 (5 lines) *TELEGRAMS:* PRECISION, SURBITON

Tick No 104 on reply card for further details

Complete Industrial Film Productions

by

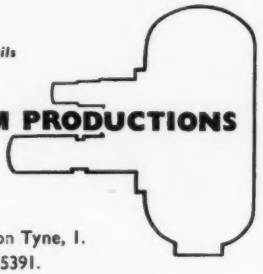
TURNERS

of Newcastle

Turners' operators know photography. . . and they know industry. The result is a constantly growing list of outstandingly successful industrial films to their credit. Films of various types have been made for, among others, the following:

C. A. Parsons & Co. Ltd.
A. Reyrolle & Co. Ltd.
Fibreglass Ltd.
Central Electricity Authority.
The Expanded Metal Co. Ltd.
Houseman & Thompson Ltd.
Express Dairy Co. (London) Ltd.
South Durham Steel & Iron Co. Ltd.
Cleveland Bridge & Engineering Co. Ltd.
The Royal Agricultural Society of England.
The North East Industrial & Development Association.

Please write for further details



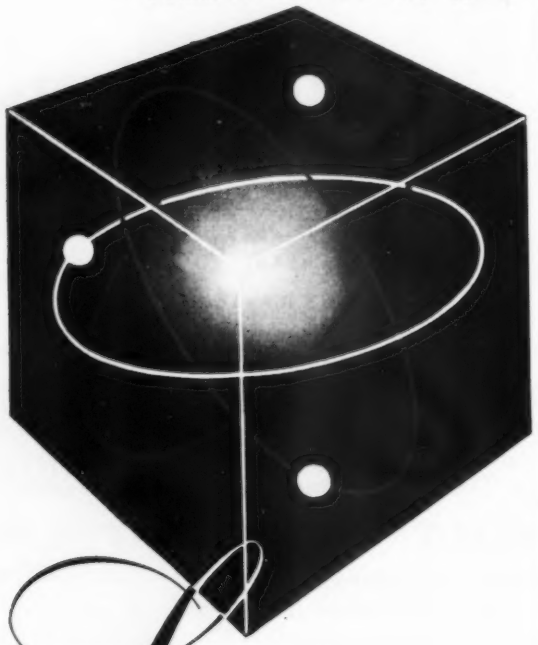
TURNERS FILM PRODUCTIONS

Camera House,
Pink Lane, Newcastle upon Tyne, 1.
Telephone: Newcastle 2-5391.

Tick **No 105** on reply card for further details

Protection

against radiation is a subject
of constant research, and the need for skilled
engineering in the manufacture of suitable
protection methods will grow as
Nuclear Power is more widely applied.



Lead

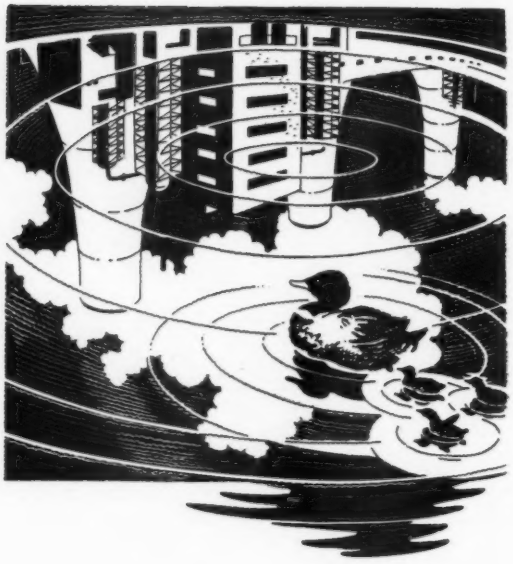
SHIELDINGS

without cavity voids, require skilled
techniques for their manufacture. In the forefront
of modern practice are JENKINSONS
who are widely known for a high degree
of skill in these directions.

Jenkinsons
CHEMICAL ENGINEERS

W. G. JENKINSON LTD.
ARUNDEL ST; SHEFFIELD 1
Phone 27438/9

Tick **No 106** on reply card for further details



the source of power changes

...but water is still of great importance

No risks can be taken with the storage of water in modern plants. Tanks must have complete and lasting internal protection.

They should, in fact, be treated with BITOTES Solution and Enamel. Bitotes prevents interior corrosion of water tanks, pipelines, cisterns, reservoirs, and all water containers, cannot crack or peel and is odourless and tasteless when dry. Fully approved for Fresh Water, Drinking Water and Demineralised Water Tanks, etc.

We will be glad to supply you with full details.

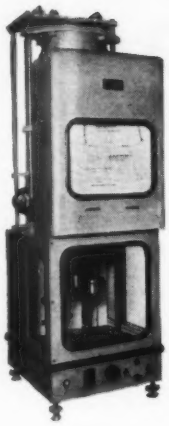
BITULAC LIMITED

(PAINTS DIVISION)

Collingwood Buildings, Newcastle upon Tyne, 1.
Telephone: Newcastle 2-5401

London Office: 219/220 Dashwood House,
Old Broad Street, London, E.C.2.

Tick **No 107** on reply card for further details



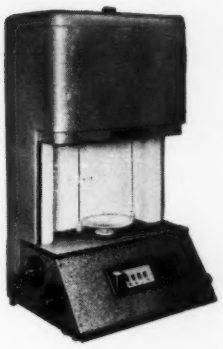
Stanton leadership

Stanton Thermo-Balance

Air-damped, suitable for total load of 50 g.; may be supplied with sensitivity of 1 mg. or 1/10th mg. Standard furnace (illustrated) suitable for 1000° C., but alternative furnaces for both high and low temperatures can be made. Once set, the Thermo-Balance will reproduce and record weight changes, time and temperature for periods up to several days.

Stanton Single-Pan Ultramatic Balance

Completely new, this latest Stanton achievement has all the good looks and performance of a precision instrument. Streamline-built for speed and accuracy, it allows greater ease of use . . . gives greater weighing speeds . . . and is backed by incomparable reliability. Dial weight loading up to 200 g.



Send for our detailed leaflets

Here are two outstanding achievements of skill allied to intelligent research . . . two brilliant examples of British craftsmanship at its best . . . two precision balances that are proven leaders in their field. On all counts, they are – without question – the finest balances in the world.

STANTON PRECISION BALANCES

STANTON INSTRUMENTS LTD., 119 OXFORD STREET, LONDON, W.1. Tel: Gerrard 7533/4

VARIACS for S-M-O-O-T-H Voltage Control

'VARIAC' is the *original*, continuously adjustable autotransformer—and the only one having 'DURATRAK', a specially treated track surface. For varying the a-c voltage applied to any electrical, electronic, radar or communications equipment a 'VARIAC' offers considerable advantages over any other type of a-c control—it has longer life, absolute reliability, much increased overload capacity, resistance to accidental short-circuits and appreciably greater economy in maintenance. Voltages from zero to 17% above line are obtained by a 320° rotation of the shaft, which is equipped with an accurately calibrated direct-reading dial. Available in various sizes from 170 VA up to 25 kilowatts, including 3-gang assemblies for 3-phase working, 'VARIACS' are competitively priced and, compared with the losses of resistive controls often save their initial cost within a year.

Most "VARIACS" are now MUCH REDUCED IN PRICE: send for our new, profusely illustrated Catalogue 424-UK/16, which gives complete information on the entire range. HUNDREDS of models—all available promptly—most EX STOCK.

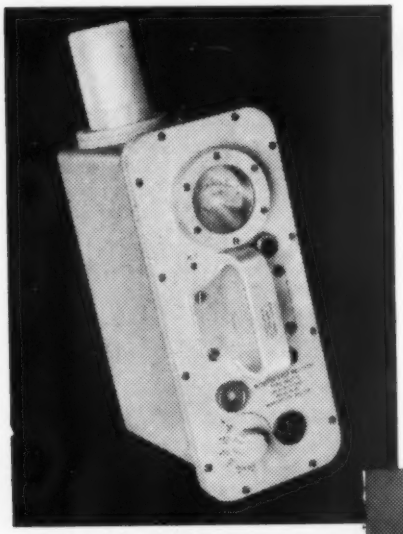
Claude Lyons Ltd.

76 Oldhall Street, Liverpool, 3, Lancs. Telephone: Central 3641
Valley Works, Hoddesdon, Herts. Telephone: HODdesdon 3007-8-9

CL31

Tick **No 108** on reply card for further details

Tick **No 109** on reply card for further details



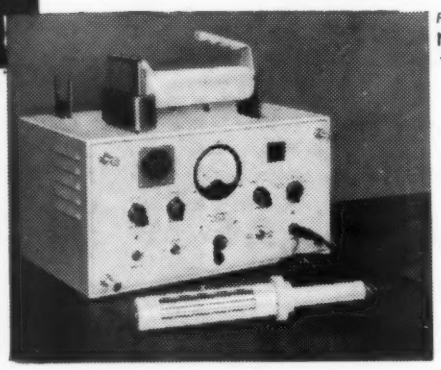
Instrumentation...

WHERE EVERY NUCLEONIC PROJECT STARTS

FAST NEUTRON MONITOR *Type 1407C*

A self-contained general purpose Fast Neutron Monitor, designed in conjunction with A.E.R.E., Harwell.

- *Meter calibrated 0-4 counts per second*
- *Measurements up to 400 counts per second in 3 decades*
- *Incorporates proton recoil proportional counter*
- *Powered by seven 1.3 volt "Kalium" mercury cells*
- *Fully sealed for operation in unprotected positions*
- *Easily decontaminated and readily transportable*



RADIATION MONITOR *Type BN.110*

Designed primarily for measurement of radiation from contaminated apparatus or surfaces, and personnel monitoring using Alpha and Beta/Gamma Probes.

- *Count rates up to 5000 per second in four ranges using meter indication*
- *Resettable register for low count rates*
- *Incorporates stabilised E.H.T. supply for probes*
- *Large Area Alpha Probe has effective area of approximately 16 square inches*
- *Easily decontaminated and readily transportable.*

For further particulars, contact
NUCLEONICS DIVISION

BURNDEPT LIMITED

ERITH KENT

manufacturers of Head Amplifiers

Ratemeters · Radiation Monitors · Neutron Monitors

More Scintillators from N.&T.

Scintillators in five forms are now available from Nash and Thompson Ltd:

CRYSTALS
Anthracene, Stilbene, Diphenylacetylene, in discs and cylinders.

PLASTICS
N.11 and N.11—X-ray, high sensitivity, high transmission polyvinyl toluene based.

LIQUIDS
Ready made, sealed in glass containers to your specification, or as scintipaks.

SCINTIPAKS
Accurately mixed dry constituents sealed in polythene envelopes, ready for dissolving in a suitable solvent as required.

POWDERS
Scintillation purity chemicals for crystal growing experiments, and the manufacture of special scintillators.

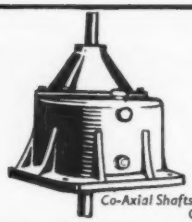
Write or telephone for full information **Nash and Thompson** *LIMITED*
OAKCROFT ROAD · CHESSINGTON · SURREY · ENGLAND · ELMBRIDGE 5252

WHG/NT61

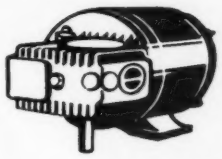
Tick **No 110** on reply card for further details

Tick **No 111** on reply card for further details

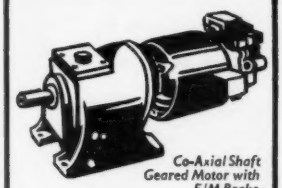
Type ESR. Motorised Unit Co-axial Shafts



Co-Axial Shafts Vertical Gear Box



Worm Geared Motor



Co-Axial Shaft Geared Motor with E/M Brake

ELECTROPOWER

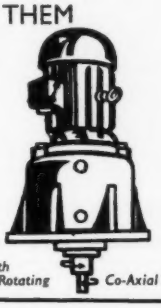
THE GEARED UNITS WITH THE POWER BEHIND THEM

The Largest Range of Geared Motors and Gear Boxes in the World

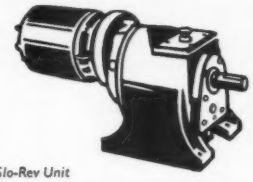
Vertical Gear Motor driving marine pump (Lloyds)

- ★ 1-20th—300 H.P.
- ★ 26,000 R.P.M.—1 revolution per day
- ★ Contra-Rotating Co-Axial Shafts
- ★ Foot and Flange Mounting Pattern
- ★ Quality Products at Competitive Prices
- ★ Variable Speed Units
- ★ All Ballraces, Gears, Pinions and Shafts contained in a ONE-PIECE CASTING
- ★ Sold all over the World

Ask for technical literature



Unit with Contra Rotating Co-Axial Shafts



Slo-Rev Unit

Electropower Gears Ltd

KINGSBURY WORKS, KINGSBURY ROAD, LONDON, N.W.9

Telephone: COLindale 4621 (4 lines) Telegrams: LEKTROPOWA, HYDE, LONDON

Technical Representation required in certain Countries.

See them at your local tool wholesaler or write to

GEM BRUSHES (LUSON) LTD., EST. 1874

ROTARY POLISHING & LATHE BRUSH DIVISION, KINGSWOOD MANUFACTURING CO., LTD.

GEM WORKS (DEPT. 9), MINERVA ROAD, LONDON, N.W.10. Tel.: ELGar 7251 (5 lines)

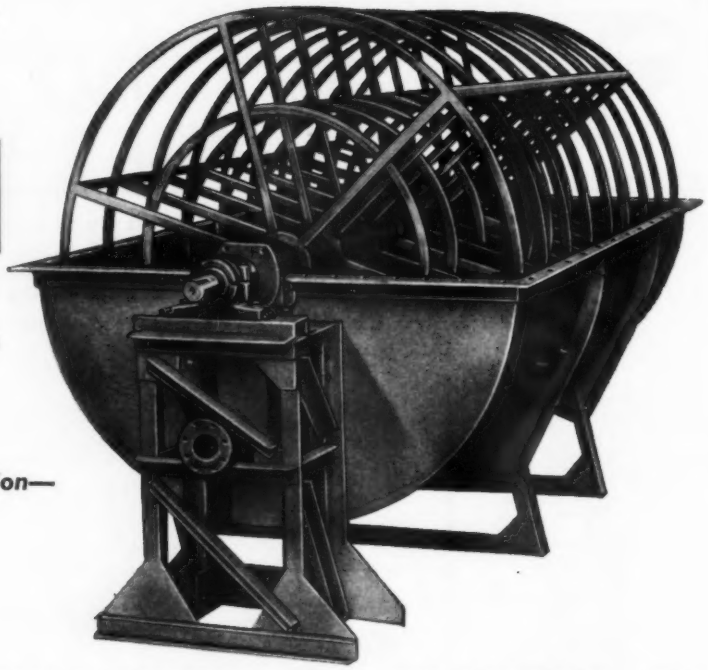
Tick **No 112** on reply card for further details

A89

Tick **No 113** on reply card for further details

Fabrications for the chemical industry in mild steel, stainless steel, aluminium etc., by

YEWCO



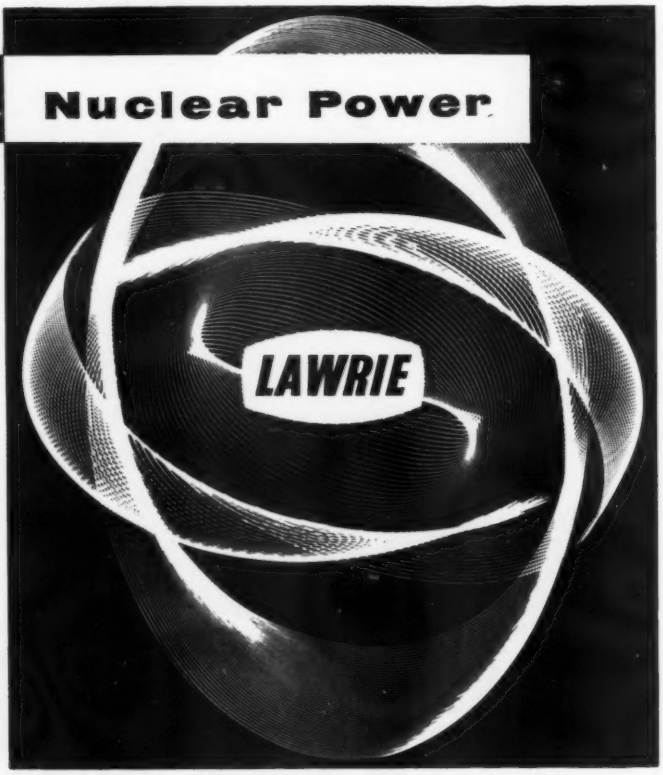
Rotary M.S. Fully Lined Scrubbing Vessel for Chemical Plant. Size 5' 6" diameter × 8' 0" long

The more exacting the specification— the more you need YEWCO

YORKSHIRE ENGINEERING & WELDING CO. (BRADFORD) LTD.

Friar's Works, Bradford Road, Idle, Bradford · *Telephone:* Idle 470 (4 lines) · *Telegrams:* 'Yewco' Bradford

PIPEWORK and Nuclear Power



For many years Lawrie's have been producing fabricated pipework to critical B.S. standards for industrial and marine applications, and to A.P.I. standards for petroleum refineries. Add to this the fact that all Lawrie's welding is approved by Lloyd's—and other major inspecting authorities—and you will see why this Clydebank firm is noted for consistent top quality pipework. The stimulus of continually working to these exacting requirements places Lawrie's in an enviable position for meeting the hypercritical standards that can be anticipated in the Nuclear Age. Indeed, Lawrie's are already on the approved list of pipework contractors to the U.K. Atomic Energy Authority.

PUT YOUR PIPEWORK PROBLEM TO LAWRIE

J. & T. LAWRIE LIMITED

LIVINGSTONE STREET · CLYDEBANK · SCOTLAND

TELEPHONE: CLYDEBANK 2171/2/3

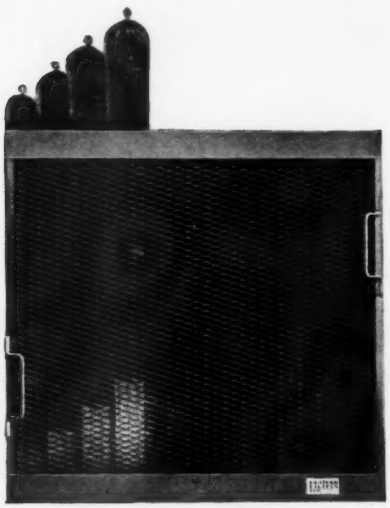
LONDON OFFICE: 34 VICTORIA STREET, S.W.1. *TELEPHONE: ABBey 4937 & 1847*

Tick **No 114** on reply card for further details

Tick No 115 on reply card for further details

YOU DON'T NEED SPECIAL EQUIPMENT OR FLUIDS TO CLEAN THIS AIR FILTER!

Heather Multi-Brush Air Filters can be cleaned easily and thoroughly, without special equipment or fluids, and still retain the initial filtering efficiency. In fact, maximum efficiency and minimum maintenance is the correct way to sum up this unique, low-cost filter system.



A finely graded mesh of intermingling hair, specially selected to withstand the varying humidity and conditions of the dust-laden air, is used to trap impurities and dust particles from the incoming air stream. Periodically, the filter brushes can be cleaned simply by shaking or suction cleaning.

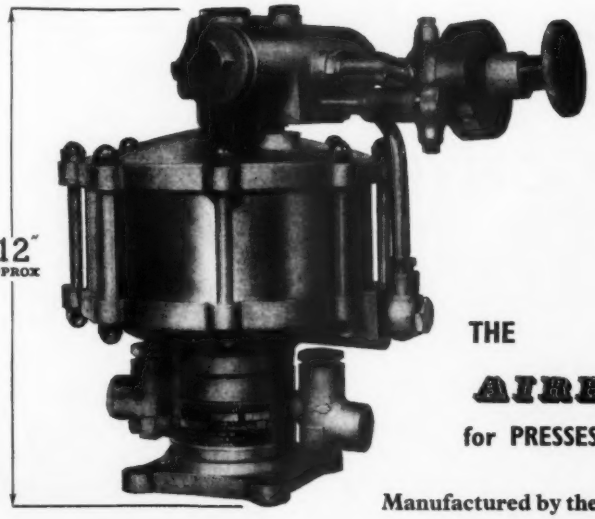
** Write NOW for leaflet H70 which gives full details.*

HEATHER FILTERS LIMITED

28 ST. JAMES'S PLACE · LONDON · S.W.1 · HYDE PARK 7588

HF.2

It's New HYDRAULIC POWER



9 Models give pressure range from **62** TO **22,500** p.s.i.

Operated by compressed air from **5 - 100** p.s.i.

Weights from 50-81 lbs.

- Reliable
- Compact
- Designed for high output
- Low initial cost
- Negligible maintenance
- Non-corrosive
- No consumption of air when maintaining static pressure

THE

AIRHYDRO POWER UNIT

for PRESSES · HYDRAULIC JACKS
HYDRAULICALLY LOADED ROLLS ETC.

Manufactured by the makers of the world famous 'AIRHYDROPUMP'

Send for leaflet A.P.U.1 complete with output graphs

CHARLES S. MADAN & CO. LTD.

Vortex Works · Atlantic Street · Altrincham · Cheshire

Telephone: Altrincham 2702 (3 lines)

206

Tick No 116 on reply card for further details

Tick **No 117** on reply card for further details

W&J OIL FREE COMPRESSORS

DISPLACEMENT RANGE 1 to 136 c.f.m.

In the Food Processing, Brewing, Chemical and Paper Industries, also for pneumatic instrument control, it is essential that the air is free from oil in both droplet or vapour form. The W&J compressors use carbon rings and completely dry cylinders to achieve this purpose.

Manufactured now for several years they have proved themselves successful in many industries.

For further details please write requesting Leaflet Nos. 4, 20, and 28.

Illustrated is the 5" bore x 4" stroke twin cylinder model.

WILLIAMS & JAMES (ENGINEERS) LIMITED
GLOUCESTER · ENGLAND
TELEPHONE: GLOUCESTER 24021-2-3 · TELEGRAMS & CABLES: "COMPRESSOR GLOUCESTER"

MEN OF MILLIONTHS

The new problems of precision engineering born of nuclear research—the intractable metals, the unusual shapes, the exacting accuracy—are no novelty to us at Armstrong Whitworth. We have been solving these for years in aircraft and missile manufacture, and one result of this is the unparalleled array of precision machine tools that you will find in our temperature controlled, dust-free machine shop. Highly competitive costs have also been made possible by new techniques we have evolved, and all these benefits will be gladly shared with you. May we solve your problem?

FOR PRECISION MACHINING CONTACT:—

SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LTD

Baginton, Coventry. Telephone: Toll Bar 2261

A MEMBER OF THE HAWKER SIDDELEY GROUP

Tick **No 118** on reply card for further details

A92

Tick **No 119** on reply card for further details

No time to lose

If Britain is to keep her lead in the nuclear energy field, the rate of productivity must be increased in all branches of the industry. This is specially true in the drawing office, for it is there that future achievements are now being planned.

The Simplon "Modular Line" units, two of which are illustrated here, can help draughtsmen to maintain their high standard. Designed as complete individual work stations, with the drafting board as the hub of the draughtsmen's activity, all unnecessary movement is eliminated and, since countless efficient room layouts are possible, all available space is utilised to the best advantage.

May 7th — 17th, 1958, at Earls Court

MECHANICAL HANDLING EXHIBITION

See our STAND No. 275

SIMPLON

DARGUE BROS. LTD.
NEW SIMPLON WORKS
HALIFAX, YORKSHIRE
Telephones: Halifax 3218-9

Artists in Stainless Steel Castings

- **Carbon Steels**
- **Alloy Steels**
- **Heat Resisting Steels**
- **Corrosion Resisting Steels**

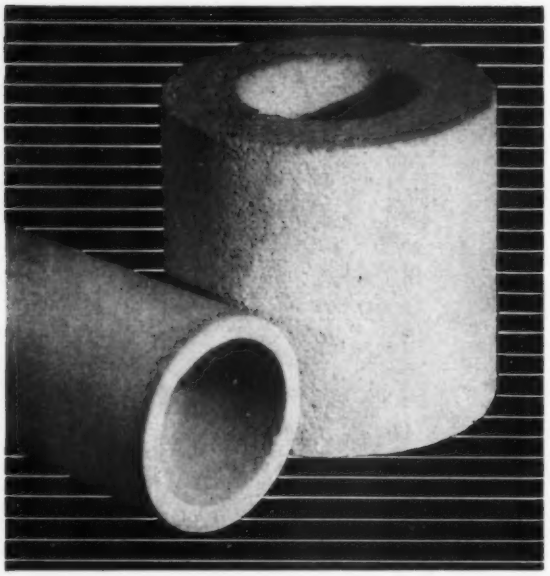
All castings can be machined in our modern machine shops

MILLENNIUM

LAKE & ELLIOT, LTD · BRAINTREE · ESSEX
Telephone: Braintree 1491

Tick **No 120** on reply card for further details

Tick **No 121** on rpely card for further details



Most Uncommon Clay

AEROX Industrial ceramics have properties of strength, uniformity of pore size and variety of shape and dimension which commend them to many industries. They could probably help you.
Would you like to know more?

Filter Elements
Electrolytic Diaphragms
Aerators
Diffusers with Ebonite Plastic or Metal Fittings
Air & Gas Filters for pressures up to 7000 lbs. per sq. in.
Carbon Adsorber Filters

AEROX LIMITED

LEADERS IN A SPECIALISED FIELD

Ceramics Works, Hillington, Glasgow S.W.2.
Telephone: HALfway 4615/6

Engineering Works, Crompton Way, Crawley, Sussex.
Telephone: Crawley 25077

Tick **No 122** on reply card for further details

THE V.P. EDISON VOICEWRITER

IT'S IDEAS THAT MAKE YOUR BUSINESS GROW!

Clear the way for thinking time with
THE VOICEWRITER

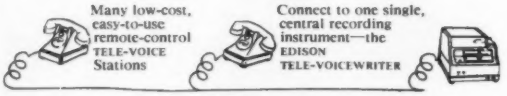
Every day businesses grow bigger, move faster, demand better communications. The EDISON VOICEWRITER helps to satisfy this demand in offices and on the desks of executives around the world.

Management messages must be relayed accurately and quickly. The Voicewriter's value lies in its ability to do this—an ability that Thomas A. Edison foresaw when he invented the business Phonograph.

The Voicewriter is an ever-present means for the quick despatch of executive decisions, ideas, delegation of work, all the administrative details. The Voicewriter is one of the many electronic advances pioneered by Thomas A. Edison Industries, the Company carrying on the high traditions of its famous Founder.

We shall be pleased to send you further particulars and if so desired arrange a free demonstration at your desk.

HAVE YOU INVESTIGATED REMOTE CONTROL DICTATION—INTRODUCED FIRST BY EDISON?


Many low-cost, easy-to-use remote-control TELE-VOICE Stations
Connect to one single, central recording instrument—the EDISON TELE-VOICEWRITER

Thomas A Edison LIMITED

VICTORIA HOUSE, VERNON PLACE
SOUTHAMPTON ROW, LONDON, W.C.1
Telephone: HOLborn 9988

Branches and Dealers:
Belfast · Birmingham · Bristol · Dublin · Glasgow
Leeds · Manchester · Newcastle · Southampton

Tick No 123 on reply card for further details

KLAXON INDUSTRIAL WARNING SIGNALS AND TRANSPORT EQUIPMENT

Buxton certified Mine Signal Equipment. Audible Signals for factories, railway yards, power stations, transport, etc. Heavy Duty Windscreen Wipers, and Direction Indicator Flasher Units.

KLAXON FRACTIONAL HORSE-POWER MOTORS

From 1/2000 to 1 Horse-Power. Synchronous. Commutator. Asynchronous Induction.

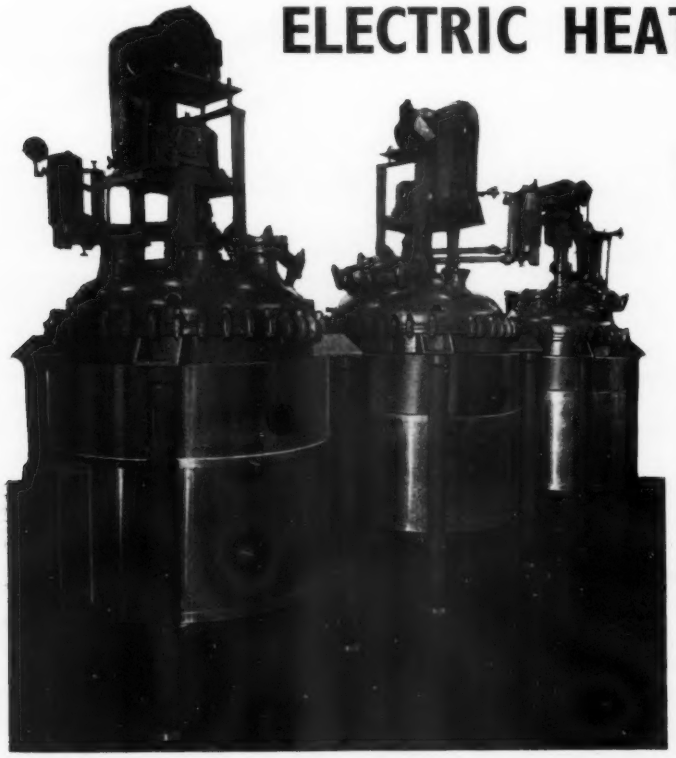
GEARED UNITS

Over 50 standard types. Output torques from zero to 2,500 lb. ins. Other types and performances designed for special requirements.

KLAXON LIMITED
Manufacturing Electrical Engineers. Estab. 1909.
49 UPPER BROOK ST., LONDON, W.1 *Tel.: Mayfair 9020*
WORKS—BIRMINGHAM. *Tel.: Acocks Green 1654*

KLAXON
every time!

ELECTRIC HEATING MANTLES



by STABILAG

For accurate controls in distillation and fractionation operations, for high temperature work, and in concerns where steam or other heating medium are not available, Stabilag Electric Heating Mantles are the complete answer.

Installation costs with Stabilag Mantles are negligible; also they have the great advantage of multi-zone heating which is arranged by tiers of circular elements operating independently and thereby giving heat exactly where it is required. Construction of these, as of all Stabilag products, is of the very highest quality. Send for literature and full details to:

THE STABILAG CO. LTD. (Dept.A5)
Mark Road, Hemel Hempstead, Herts. BOXmoor 4481

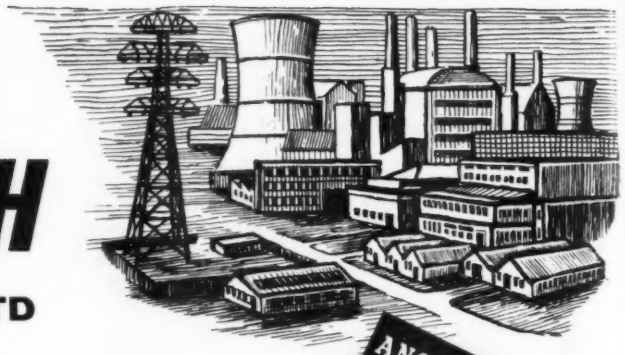
Tick No 124 on reply card for further details

A95

Tick **No 125** on reply card for further details

ANGLO-SWEDISH

ELECTRIC WELDING CO. LTD



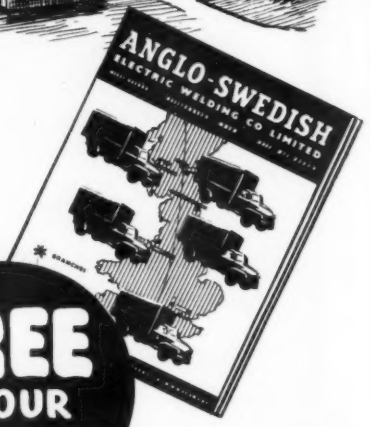
FIRST CLASS WELDING UNDER THE STRICTEST SUPERVISION

WE HAVE ample facilities for handling top-grade welding repairs to boilers, castings, machine parts, etc., with expert technicians for Fabrication work, Structural Steel work, Tank construction and Electric Stud Welding.

Phone, Call, or Write us NOW for immediate service

ANGLO-SWEDISH ELECTRIC WELDING CO. LTD

LONDON · GLASGOW · LEITH
NEWCASTLE · LIVERPOOL

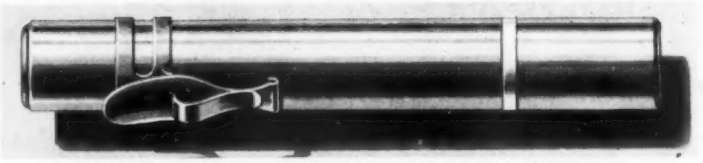


FREE COLOUR BROCHURE

THIS DESCRIPTIVE COLOUR BROCHURE WILL BE SENT **FREE** ON REQUEST

STEPHEN

QUARTZ FIBRE POCKET DOSIMETERS



Characterised by a very low natural leak, a high quality optical system and considerable mechanical strength, Stephen individual dosimeters are available in the ranges 0-0·2r, 0-0·5r, 0-5r, 0-50r, 0-150r, and 0-500r. Other ranges can be supplied to order. All except the 0·2r range are "air wall" construction.

STEPHEN
MITCHAM · LONDON

Pocket-size transistor charging unit has ample capacity with full control for charging all British-made pocket dosimeters. Weight 6 oz. (170 gms).

R. A. STEPHEN & CO. LTD., 120-126 LAVENDER AVE., MITCHAM, SURREY

FWS

Tick **No 126** on reply card for further details

A96

Pumps for special duties

We are specialists in high pressure positive displacement pumps of compact dimensions for handling liquids of varying viscosities and with other difficult characteristics. Pumps are also made in special materials for arduous duties.

JOSEPH EVANS & SONS (WOLVERHAMPTON) LTD

CULWELL WORKS, WOLVERHAMPTON
Telephone: 20864/6

LONDON OFFICE: Pulsometer House
20/26 Lamb's Conduit St, W.C.1

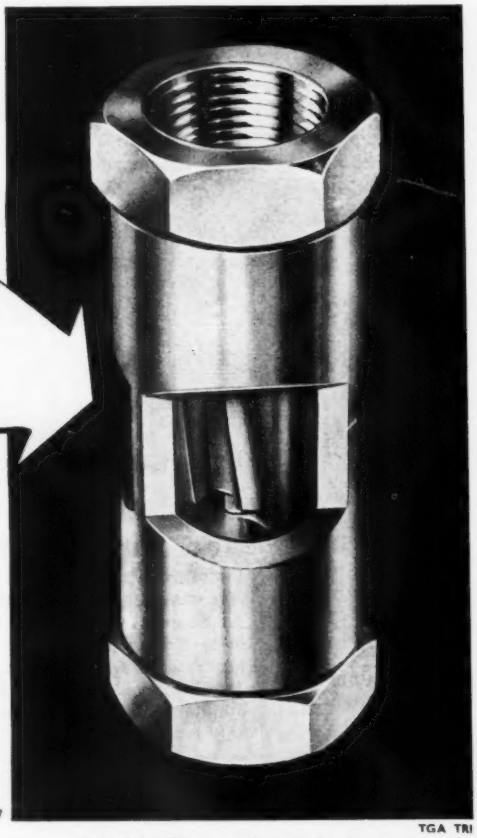
See

the flow with the 'Telicator'

Low or high pressure fluid systems can be fitted with a Telicator Visual Flow Indicator, which is a simple instrument for indicating the flow, whatever the viscosity. The rotors are specially designed by Dukes and Briggs to give the clearest indication over specific ranges of flow rate. Water supplies for cooling purposes, and forced lubrication systems are two typical applications. A new model is under development for use with opaque fluids, and special designs can be made to meet specific requirements.

Note these features

- *Comparative flow gauged by speed of revolving rotor*
- *Extreme sensitivity at all pressures*
- *Units readily adaptable to existing installations*
- *May be mounted in any plane*
- *Simple design ensures complete reliability*



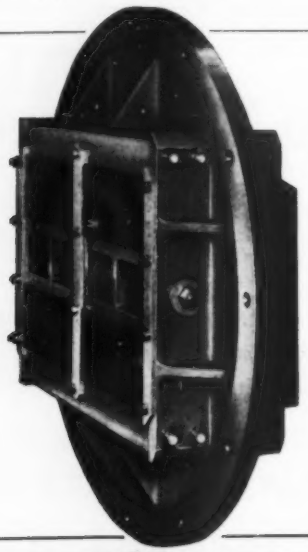
Bailey's

SIR W. H. BAILEY & CO. LTD, PATRICROFT, MANCHESTER, ENGLAND
Phone: Eccles 3487-8-9 Grams: Beacon, Eccles
LONDON OFFICE: SELINAS LANE (OFF WHALEBONE LANE SOUTH), DAGENHAM, ESSEX. PHONE: DOMINION 2277

TGA TRI

Tick No 128 on reply card for further details

Tick **No 129** on reply card for further details



AMAL

A Special Unit constructed by us for the U.K.A.E.A.

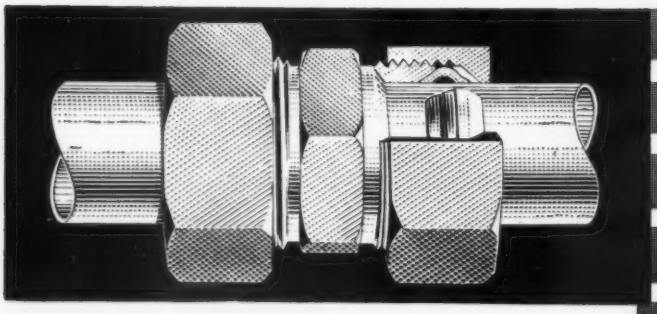
We have had extensive experience in the manufacture of many engineering products such as

FLOWMETERS · FUEL PUMPS
JET CALIBRATING MACHINES
FUEL FILTERS · FLAP VALVES
FLAME TRAPS · GAS INJECTORS
FUEL PRESSURE REGULATORS

Now added to this List is Equipment for the U.K.A.E.A.

Enquiries to:
Amal Ltd · Witton · Birmingham · Phone Birchfield 4571 (6 lines)
A310

FASTEST ON THE JOB!



compression joints

and the safest

Simplifix Joints save time and trouble. Beyond removing the burrs no work is required on the pipe ends. As the securing nut is tightened, the sealing ferrule is compressed on to the pipe without weakening it in any way.
Note: Simplifix fittings can be used on very thin walled tubing.
A full range of fittings, elbows, tees, crosses, etc., is available and illustrated in our catalogue which will be sent on request.

SIMPLIFIX COUPLINGS LIMITED
HARGRAVE ROAD
MAIDENHEAD
BERKS
Tel:Maidenhead 2271/4

SIMPLIFIX

Tick **No 130** on reply card for further details

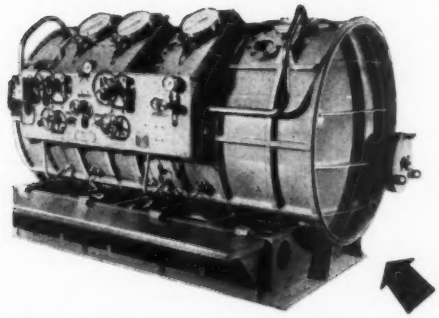
A98

Welding BOOTH light metals in the Atomic age

Photograph by courtesy of U.K.A.E.A.

THE ZETA TORUS

The ring-shaped torus of Zeta, in which temperatures of up to 5 million degrees centigrade have been produced at Harwell, was welded in 99.5 purity, 1-in. thick aluminium plate produced and supplied by James Booth & Co. Ltd. Welding was carried out by manual inert-gas-shielded arc process with a consumable electrode and automatic arc regulation, at the Works of Metropolitan-Vickers. James Booth aluminium has also been used for the welded torus liner, supports, and branch pipelines of Zeta and for its smaller prototype. Circumferential Argonaut welds on the torus are clearly seen.

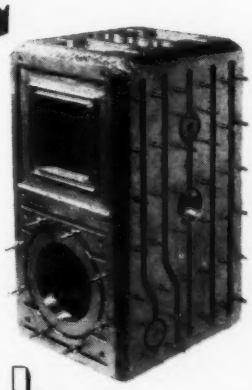


DIVERS' RECOMPRESSION CHAMBERS

This all-welded recompression chamber, fabricated in Booth 'MG5' alloy, is one of a number constructed for the Admiralty by Saunders-Roe (Anglesey) Ltd. Perfect welds are vital in these high-pressure vessels in which divers are placed to gradually accustom them to surface pressures.

IN TRANSISTOR MANUFACTURE

A remarkably low leak rate of under 10^{-6} litre millibars/sec. has been achieved in this high-vacuum furnace chamber used in the first stage of transistor manufacture. It has been welded by James Booth from 1-in. thick 'MG5' plate, for Services Electronics Research Laboratories, using Argon-arc process.



These are just three recent important engineering applications in which the welding of James Booth light metals have provided the answer to special problems. In addition to producing and supplying high-purity aluminium and aluminium alloys, James Booth have unique knowledge and practical experience in welding and fabricating these materials.

EXTRUSIONS, LARGE FORGINGS, PLATE, SHEET, STRIP, TUBES, AND WIRE IN BRASS AND COPPER, AS WELL AS LIGHT ALLOYS.

James Booth

JAMES BOOTH & COMPANY LIMITED

ARGYLE STREET WORKS · BIRMINGHAM 7

TGA JBG 130

Tick **No 132** on reply card for further details

INTEGRAL
FAURE—HERMAN

ELECTRONIC FLOWMETER
for flowrate measurement and control

High accuracy, low pressure drop

Available for flow rates of from ⅛ gall/min. to 120 gall/min.

Fluid temperature up to 100° C—lower limit has not been established but the equipment has been used satisfactorily with liquid oxygen (-183° C)

Suitable for most (except highly corrosive) liquids

Manual or automatic S.G. correction can be provided

Automatic flow control can be achieved by using in conjunction with a suitable servo amplifier and pump

Write us concerning your particular requirements—our instrument engineer will be pleased to help you

INTEGRAL LIMITED · BIRMINGHAM ROAD · WOLVERHAMPTON

Tick **No 133** on reply card for further details

FABRICATED STEEL PIPES, BENDS, TEES,

TYPICAL FABRICATION

16 ins. Breeches Piece to 24 ins. by 90° Bend for Large Diesel Engine.

ETC. TO DRAWINGS

HOPPERS
CONES
CHUTES
DUCTINGS
CHIMNEYS

Send Sketch for Quotation–

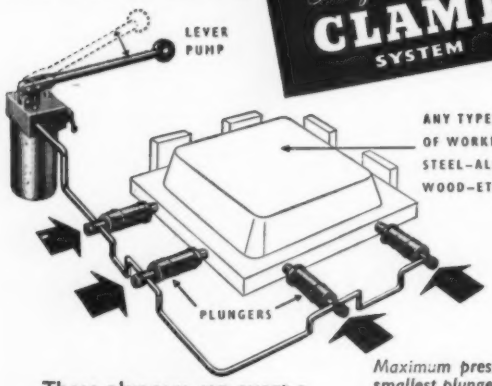
MILD STEEL PLATE FLANGES
PROFILE CUTTING
ELECTRIC WELDING
PLATE ROLLING

PIPE FABRICATORS (STAMFORD) LTD.
EASTON-ON-THE-HILL, STAMFORD, LINCS.

Phone: Stamford 3464 Telegrams: Fabricators, Easton

BIGGEST TIME & MONEY SAVER in WORK CLAMPING

NEWTON PRODUCT
Hydraulic CLAMP SYSTEM



These plungers can exert a pressure of from 800lbs—4 tons.

Can be used in groups of any number.

Maximum pressure with smallest plungers

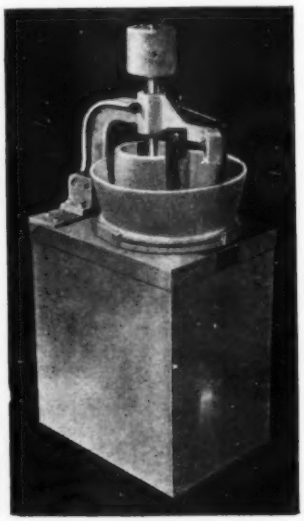
Easily adaptable to any fixture design

Simultaneous plunger action

Minimum floor to floor time.

Send today for illustrated brochure 243/P2

POWER JACKS *LIMITED*
MAYLANDS AVENUE · HEMEL HEMPSTEAD
TEL. BOXMOOR 3000 GRAMS. NEWSORBER, HEMEL HEMPSTEAD



laboratory end runner mills

Available with four mortar sizes, 6", 10", 15", 20". Mill supplied complete with electric motor and starter and with either ceramic or metal mortar and pestle.

The mortars and pestles are interchangeable. A ceramic set can be used to process material adversely affected by contact with metal and a metal set, either high grade cast iron or stainless iron can be carried as a spare set for use on material for which ceramic is unsuitable. The pestles are arranged to swing clear of or lift out of the mortars to facilitate emptying or cleaning.

The model illustrated is the No.2 mill with a 15" diameter mortar

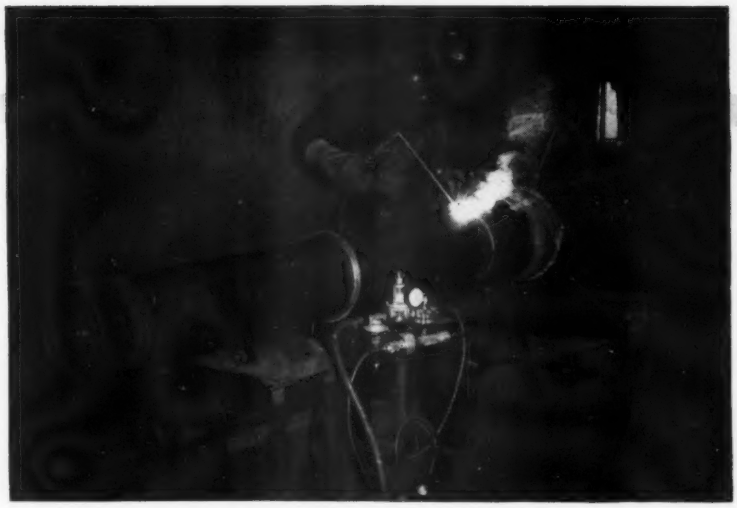
PASCALL

Write or telephone Crawley 25166 for List EN 3204

THE PASCALL ENGINEERING CO. LTD.
GATWICK ROAD · CRAWLEY · SUSSEX.

Tick **No 134** on reply card for further details

Tick **No 161** on reply card for further details



WELDING CHARGE TUBES

The photograph shows an operator welding one of the 448 charge tubes, using low hydrogen electrodes throughout.

The Unit Superheater and Pipe Co. Ltd., following initial contracts for reactor charge tubes for Calder Hall and Chapelcross power stations, has been entrusted by Whessoe Limited, member company of the Nuclear Power Plant Co., to produce the charge/discharge and control rod stand tubes for Bradwell Power Station.

THE **UNIT** SUPERHEATER AND PIPE CO. LTD · UNIT WORKS SWANSEA Telephone : Swansea 54091 (6 lines). Telegrams : 'Superunits', Swansea. Telex: 48-208.

UNIT

BINDING Nuclear Power

The journal of British nuclear engineering

You often want to refer to NUCLEAR POWER . . .

. . . these Easibinders will hold up to 6 copies of NUCLEAR POWER (8 of Vol. 1) for quick and easy reference

12/6 each plus 1/6 postage and packing

TO ROWSE MUIR PUBLICATIONS LTD., 3 PERCY STREET, LONDON, W1

Please supply_____Easibinders for NUCLEAR POWER (Vol. 1 / other Vols.)

NAME_____

ADDRESS_____

_____

PRICE 12/6 BINDER, I ENCLOSE_____

Tick **No 163** on reply card for further details

CENTRIFUGAL PUMPS
MULTI-STAGE
SPLIT-CASING

FOR
EASY
MAINTENANCE

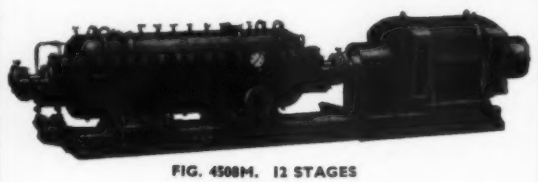


FIG. 4508M. 12 STAGES

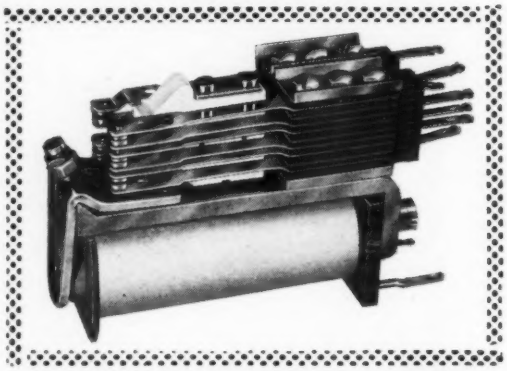
LEE, HOWL & CO., LTD.
TIPTON, STAFFS.

Will design Pumps for Special Duties

LONDON OFFICE:
375 REGENTS PARK ROAD, FINCHLEY, N.3

Tick **No 164** on reply card for further details

RELAYS
TO SPECIFICATION



POST OFFICE TYPE
3,000 and 600 RELAYS

Specialists in tropical and Services jungle finish.
Guaranteed to full A.I.D. and I.E.M.E. standards.
Prompt Deliveries. Prototypes 7 to 10 days.

Post Office approved. All relays guaranteed made in our own works.
P.T.F.E. insulation now available.

SIMMONDS

Manufacturers to H.M. Government Departments and leading Contractors
L. E. SIMMONDS LIMITED, 5 BYRON ROAD, HARROW, MIDDX.
TELEPHONE: HARROW 7797/9 TELEGRAMS: SIMRELAY HARROW

on site

mobile teams and equipment providing

metal polishing

welding — metal spraying

shot blasting services

Enquiries invited for Atomic Energy Development Sites

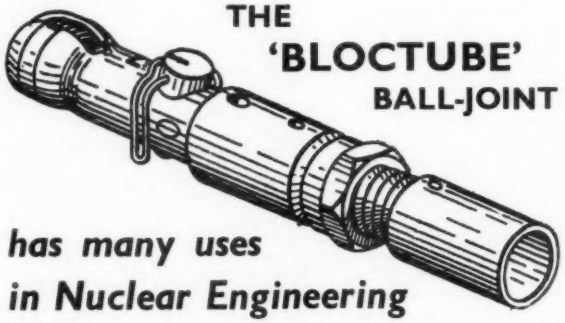
send for brochure to:

STAINLESS EQUIPMENT CO.
(METAL FINISHERS) LTD

72, De Beauvoir Crescent,
LONDON, N.1.

(M.O.S. approved) *Telephone: Clissold 4141, Bishopsgate 0707*

THE
'BLOCTUBE'
BALL-JOINT



has many uses in Nuclear Engineering

Almost all nuclear installations employ this fitting due to its robustness and its adaptability.

'BLOCTUBE' controls were selected for controlling fine control valve in Neptune.

Your enquiries are invited for complete installations or for fittings as illustrated.

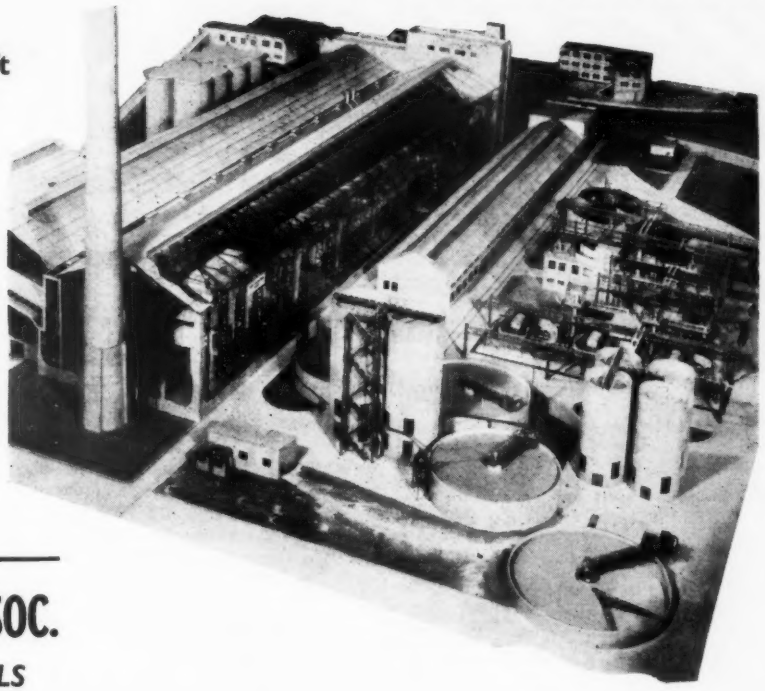
BLOCTUBE CONTROLS LIMITED
AYLESBURY - BUCKS

Tick **No 165** on reply card for further details

Tick **No 166** on reply card for further details

Tick **No 167** on reply card for further details

Part of a sectional model 12ft by 12ft made for The Cement Marketing Co. Ltd. Scale $\frac{1}{8}$ in = 1ft



We are at present engaged on a similar type of model of Bradwell for the Nuclear Power Plant Co. Ltd.

RICHARD DENDY & ASSOC.

MAKERS OF FINE MODELS

4, 5 & 6 SEATON PLACE LONDON N.W.1
PHONE EUSton 7617

Tick **No 168** on reply card for further details

A103

Tick No 169 on reply card for further details

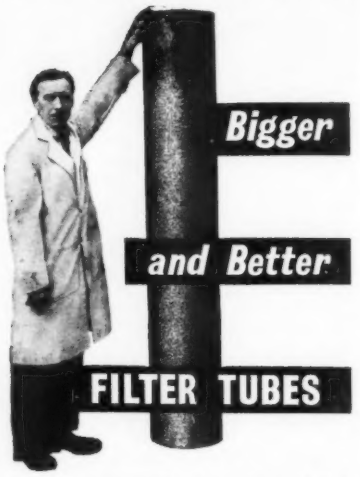
S.M.P

PRECISION ENGINEERS

Capstan, Auto and Centre Lathe Turning.
Horizontal and Vertical Milling.
Drilling and Tapping.
Centreless, Surface and Internal Grinding.
Case Hardening and Stove Enamelling.
Own Design and Drawing Office, Toolroom and Experimental Department.
(Approved A.I.D., D.I.Arm., A.R.B.)
Machining Specialists in Stainless and Various High Tensile Steels.

SCREW MACHINE PRODUCTS LTD.
Wooburn Green, Nr. High Wycombe, Bucks.
Telephone: Bourne End 111

Tick No 171 on reply card for further details



An example of the largest CORUNDUM grade POROUS tubes we have yet made. It is not often that we produce such giant tubes, but smaller sizes up to 4′ 6″ in length are used extensively in gas filtration.

Here are but a few applications:

Air-line filters, removing solid particles and liquid droplets. Cleaning of exit gases on pneumatic handling processes. Removal of impurities from gases at both normal and elevated temperatures. Recovery of catalytic dust in fluidized processes. Cleaning of gases for sampling purposes. Removal of liquid droplets from gas streams, e.g. water from compressed carbon dioxide or acid mist from exhaust gases. Sterilization, of small gas volumes only.

Write for catalogue No. 10 to:

DOULTON INDUSTRIAL PORCELAINS LIMITED

Dept. NE, Royal Doulton Potteries, Wilnecote, Tamworth, Staffs.

ARE YOU WELDING BARS OF 1″ DIAMETER OR OVER?

THE "SECROM" PROCESS

is not only the QUICKEST and most ECONOMICAL but also

ensures weld strength equal to, if not greater than, the bar metal

Further details from:-

M. SEMET & CO. LTD.
27 ASHLEY PLACE
LONDON, SW1
Telephone: Tate Gallery 8631

LEAD FOR PROTECTION

The Technical Personnel of
THE LEAD DEVELOPMENT ASSOCIATION
are available at all times

to assist in your problems

on the protective qualities of Lead against Gamma-Ray and X-Ray

LEAD DEVELOPMENT ASSOCIATION
18 ADAM STREET, LONDON W.C.2
TELEPHONE: WHITEHALL 4175
TELEGRAMS: LEADEVEP, RAND, LONDON

Tick No 170 on reply card for further details

A184

Tick No 172 on reply card for further details

CLASSIFIED ADVERTISEMENTS

RATES	Classified advertisements are charged at 4s. per line. Semi-display setting £2 per single-column inch. 5% is allowed to trade advertisers for six insertions, 10% for 12 consecutive insertions. Box numbers will be charged 1s. extra
REMITTANCES	Cheques and postal orders should be sent to Rowse Muir Publications Ltd with the order for the advertisement
PRESS DAY	Advertisements must be received not later than May 12 for the June issue
TERMS	All advertisements are strictly net and must be prepaid
HEAD OFFICE	All advertisements should be addressed "Classified Advertising," NUCLEAR POWER, 3 Percy Street, London, W1
BOX OFFICE REPLIES	NUCLEAR POWER, 3 Percy Street, London, W1

SITUATIONS VACANT

A.E.I.—JOHN THOMPSON NUCLEAR ENERGY CO. LTD., RADBROKE HALL, KNUTSFORD, CHESHIRE

CONTROL ENGINEER

An honours graduate with a good degree in mathematics, physics or engineering is required for work on problems associated with reactor kinetics and the control of nuclear reactor power plants.
Previous experience in one or both of the following subjects is necessary:—

1. Analysis of closed loop control systems.
2. Analysis of problems involving dynamics, thermodynamics and the flow of fluids.

A knowledge of analogue computing principles and techniques would be welcomed but is not essential.
This position is on the permanent staff and there is a contributory pension scheme in operation. Transport is provided from the Stretford/Sale/Altrincham area.
Applicants should write, giving full particulars of themselves, to the Chief Engineer, reference JRMS.

CHIEF CHEMIST

A graduate chemist (age up to 30 years) with several years experience of trace element analysis, is required in the North Midlands area, to take charge of several new laboratories concerned with the analysis of an important raw material connected with the nuclear power industry. He will be responsible for guiding a team of assistants, and will be given the opportunity to advise on the lay-out and setting up of new laboratories.
This appointment provides a unique opening in this field and offers a four figure salary for this position.
Contributory pension and free life assurance scheme in operation.
Apply with full details of past experience, education and qualifications, marked Private and Confidential, to Ref. QC/2, Box No. 73.

DRAUGHTSMEN

All grades, interesting nucleonic work. Apply Chief Engineer, General Radiological Ltd., 15/18 Clipstone Street, London, W.1.

SALES ENGINEERS

and

CONTRACTS ENGINEERS

are required by the English Electric Company Limited at Whetstone near Leicester for work on comprehensive projects for

NUCLEAR POWER STATIONS

Applicants should preferably have commercial experience in either the civil, mechanical or structural aspects of conventional power stations or large engineering projects.

This is an excellent opportunity for men wishing to gain experience in this interesting and expanding field.

Please write giving full details of education, experience and present salary to Dept. C.P.S., Marconi House, 336/7 Strand, London W.C.2, quoting reference NP1897L.

ENGLISH ELECTRIC

A.E.I.—JOHN THOMPSON NUCLEAR ENERGY CO. LTD., RADBROKE HALL, KNUTSFORD, CHESHIRE

MATHEMATICIAN OR PROGRAMMER

A mathematician is required for work on the solution by digital computer of a variety of transient problems associated with the thermodynamics and kinetics of nuclear reactors. Previous experience of numerical analysis and the application of digital computers is desirable but is not essential. Previous experience of thermodynamics calculations would be welcomed.
This position is on the permanent staff and there is a contributory pension scheme in operation. Transport is provided from the Stretford/Sale/Altrincham area.
Applicants should write giving full particulars of themselves to the Chief Engineer, quoting reference JRMS.

SENIOR LABORATORY TECHNICIAN

A senior laboratory technician is required to assist in the development and engineering for production of radiation detectors for the nuclear engineering industry. Experience in this field would be an advantage but is not essential. A knowledge of light engineering and general physics laboratory practice including high vacuum techniques is desirable. The position involves the development of new constructional techniques and the initiation of new designs to meet a wide range of detector problems presented by the Company's rapidly expanding programme. Pleasant working conditions and an attractive salary are offered to the right man. Applications should be made in writing to The Personnel Department, Plessey Nucleonics Limited, Weedon Road, Northampton.

HUMPHREYS & GLASGOW

LTD require a

PRODUCTION ENGINEER

A senior man of personality and drive with knowledge of shop practice in General Mechanical Engineering and Pressure Vessel Construction to take charge as Departmental Head of Inspection, Expediting, Progressing and Transport of purchased equipment. Staff about 35.

The salary paid will depend on ability and experience but will not be less than £2000.

Apply to: Gordon Helps, Joint Managing Director, Humphreys & Glasgow Ltd., 22 Carlisle Place, London, S.W.1.

SUB-CONTRACTING

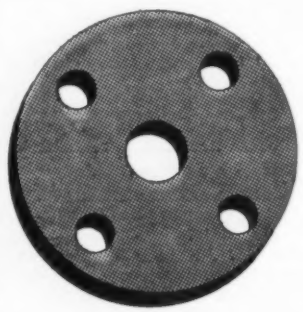
ELECTROPOLISHING—specialists in electro-polishing of all sizes of stainless steel fabrications at greatly reduced cost compared with mechanical polishing. Fully approved for Atomic Energy work. Electropol Processing Ltd., Trading Estate, Farnham, Surrey.

LITERATURE, HANDBOOKS

SERVICING LITERATURE. Industrial Handbooks Ltd write, illustrate and publish manuals and parts lists for nuclear components and systems. Rapier House, Turnmill Street, London, E.C.1. Clerkenwell 0548.

INDEX TO ADVERTISERS

Abingdon King Dick	A76
Accles & Pollock Ltd	A3
Acheson Colloids Ltd	A63
AEI-John Thompson	A31
Aero Precisions Ltd	A47
Aerox Ltd	A94
Aluminium Wire & Cable Co Ltd	A36
Amal Ltd	A98
Anglo-Swedish Electric Welding Co Ltd	A96
Armstrong Whitworth Aircraft Ltd, Sir W. G.	A92
Ayling Nuclear Equipment Co	A59
Bailey & Co Ltd, N. G.	A53
Bailey & Co Ltd, Sir W. H.	A97
Birfield Industries Ltd	A32
Birmetals Ltd	A26
Bitulac Ltd	A86
Bloctube Ltd	A102
Boby & Co Ltd, William	A83
Booth & Co Ltd, James	A90
Boving & Co Ltd	A46
British Industrial Eng Co Ltd	A60
British LaBour Pump Co Ltd	A13
British Paints Ltd	A23
British Oxygen Gases Ltd	243
Burndept Ltd	A88
Butterfield Ltd, W. P.	A52
Butters Bros & Co Ltd	A72
C & P Development Co (London) Ltd	A74
Cape Asbestos Co Ltd	A14
Central Electricity Generating Board	A43
Consolidated Pneumatic Tool Co Ltd	A48
Courtburn Positioners Ltd	A81
Cox and Danks Ltd	A80
Dargue Bros Ltd	A93
Darlington Insulation Co Ltd	A62
Delaney Gallay Ltd	245
Dendy & Associates, Richard	A103
Detel Products Ltd	A67
Doulton Industrial Porcelains Ltd	A104
Edison Ltd, Thomas A.	A94
Enfield Rolling Mills Ltd	A44
Electrical Power Eng Co (Birmingham) Ltd	A83
Electropower Gears Ltd	A89
Empyrium Welding & Manufacturing Co Ltd	A41
Energia Nucleare	A82
Engineering Appliances Ltd	A37
Erhard, Johannes	A22
Eutectic Welding Alloys Co Ltd	A79
Evans & Sons (Wolverhampton) Ltd, Joseph	A97
Evershed & Vignoles Ltd	A29
Fielden Electronics Ltd	A61
Fielding & Platt Ltd	A21
Firth-Derihon Stampings Ltd	A11
Flight Refuelling Ltd	251
Gamma-Rays Ltd	A76
Gem Brushes (Luson) Ltd	A89
General Electric Co Ltd	A17
Graviner Mfg Co Ltd	A24
Grey & Marten Ltd	A69
Head Wrightson Processes Ltd	A5
Heather Filters Ltd	A91
Holman Bros Ltd	Cover 4
Hopkinsons Ltd	A19
Howden & Co Ltd, James	Cover 2
Imhof Ltd, Alfred	A42
Institute of Welding, The	241
Integral Ltd	A100
Intermit Ltd	A32
Isopad Ltd	A56
Jenkinsons Ltd, W. G.	A86
Jessop & Sons Ltd, William	A4
Keith Blackman Ltd	A16
Kent, Ltd, George	Cover 3
Kingston Instrument Group	A80
Klaxon Ltd	A95
Klinger Ltd, Richard	A25
Kontak Mfg Co Ltd	A77
Lake & Elliott Ltd	A93
Laurie Ltd, J. & T.	A90
Lead Development Association	A104
Lee, Howl & Co Ltd	A102
Lincoln Electric Co Ltd	A55
Lyons Ltd, Claude	A87
Madan & Co Ltd, Charles S.	A91
Magnesium Elektron Ltd	A82
Mancuna Engineering Co Ltd	A30
Marston Excelsior Ltd	A6
Matthews & Yates Ltd	A50
Meritus (Barnet) Ltd	A78
Metal & Pipeline Endurance Ltd	A78
Metropolitan-Vickers Electrical Co Ltd	A27
Mirrlees, Bickerton & Day Ltd	A15
Moler Products Ltd	A65
Mollart Engineering Co Ltd, The	A85
Mulberry Co, The	A103
Mullard Ltd, X-ray Division	A28
Murex Welding Processes Ltd	A1
Nash & Thompson Ltd	A88
Newalls Insulation Co Ltd	A2
Norton Grinding Wheel Co Ltd	A66
Nuclear Enterprises (GB) Ltd	A84
Nuclear Power Plant Co	A51
Nu-Swift Ltd	247
Oxhycarbon Co Ltd	A56
Palatine Tool & Engineering Co (Surbiton) Ltd	A84
Pantak Ltd	A79
Pascall Engineering Co Ltd, The	A100
Philips Electrical Ltd	Cover 1
Pipe Fabricators (Stamford) Ltd	A100
Power Jacks Ltd	A100
Pyrene Co Ltd	A18
Quasi-Arc Ltd	A70
Rawlplug Co Ltd	A9
Rockweld Ltd	A38
Ross & Partners Ltd, Donald	A40
Sankey-Sheldon Ltd (Unistrut Division)	A54
Saturn Industrial Gases Ltd	A57
Savage & Parsons Ltd	A68
Scottish Machine Tool Corporation Ltd	A45
Screw Machine Products Ltd	A104
Semet & Co Ltd	A104
Shell Mex & BP Ltd	249
Simmonds Ltd, L. E.	A102
Simplifix Couplings Ltd	A98
Skinningrove Iron Co Ltd	A58
Solartron Electronic Group Ltd	253
Stabilag Co Ltd, The	A95
Stainless Equipment Co (Metal Finishers) Ltd	A102
Stainless Steel Profile Cutters Ltd	A106
Stanton Instruments Ltd	A87
Steels Engineering Installations Ltd	A75
Steels Engineering Products Ltd	A39
Stephen & Co Ltd, R. A.	A96
Techniques Nucléaires Co Ltd	A74
Texas Instruments Ltd	A64
Turners Film Productions	A85
Unit Super Heater & Pipe Co Ltd, The	A101
Versil Ltd	A34, A35
Vokes Ltd	A33
Wakefield-Dick Industrial Oils Ltd	A73
Wandleside Cable Works Ltd	A8
Watson & Co, Robert	A20
Weston & Co Ltd, Charles	A12
Wharton Crane & Hoist Co Ltd	A10
Willan Ltd, G. L.	A7
Williams & James (Engineers) Ltd	A92
Wilson & Partners Ltd, A. C.	A81
Worthington-Simpson Ltd	A49
Yorkshire Engineering & Welding Co (Bradford) Ltd	A90



STAINLESS TUBES & FLANGES

We offer in approved grades of Stainless Steel

★ FLANGES MACHINED TO B.S. TABLES OR TO SPECIAL SIZES
★ SOLID DRAWN TUBES—FABRICATED PIPES
★ ROUND and HEXAGON BAR
★ PROFILES CUT TO ANY THICKNESS OR SIZE
★ CASTINGS TO CUSTOMERS SPECIFICATION

Keen Prices — Prompt Delivery

Send enquiries to Dept. N.P.

STAINLESS STEEL PROFILE CUTTERS LTD.

Farfac Works, Kings Grove, MAIDENHEAD. *'phone* 1522/23.

Tick **No 173** on reply card for further details

The entire contents are protected by copyright in Great Britain and all the countries signatory to the Bern Convention; nothing therefrom may be reproduced in any manner without the written permission of Rowse Muir Publications Limited. Nuclear Power must not, without the consent—in writing—from the publishers, be re-sold, lent, hired out or otherwise disposed of in a mutilated condition or in any unauthorized cover, by way of trade, or annexed to or as part of any other publication or advertising, literary or pictorial matter whatsoever. Special attention is called to the fact that your acceptance of this magazine with notice of the above terms constitutes a contract upon these terms between you and the person who sold it or supplied it. Subscriptions to publishers Rowse Muir Publications Ltd. Single copies UK 3/6 plus 10d. postage, 5/6 overseas, 75c US and Canada. Per annum £2.2.0 UK plus 10/- postage, £3.3.0 overseas, $8.0 US and Canada plus 50c postage.

NUCLEAR POWER is published by Rowse Muir Publications Ltd, 3 Percy Street, London, W1, England, and printed by The Haycock Press, Ltd., S.E.5

Tick **No 149** on reply card for further details

When something is accomplished which has not been done before, two important contributions are involved. First, there must be visionaries, with the ability to see that such a plan is workable. Second, there must be practical men, engineers with the experience and skill to translate the plan into reality.

Our nuclear power stations are a good example. Many years of calculation and patient research went into the melting pot before the first nuclear reactor emerged. The progression from planning to the first commercial scale power plant presented engineering problems never met before.

All these problems have of course been solved, and the successes thus won have so enriched our knowledge and experience as to bring even greater achievements within our reach.

Accurate measurement of many factors, some enormous, others minute, helped to make these successes possible. We at KENT are proud of our share in this latest contribution by engineers to the convenience and prosperity of this nation.

No one knows engineers and engineering better than KENT. For more than 40 years we have served them with the instruments essential to their work. Our reward is the evidence we find on every side of their confidence in us.

One of the reactor control panels at Calder Hall.

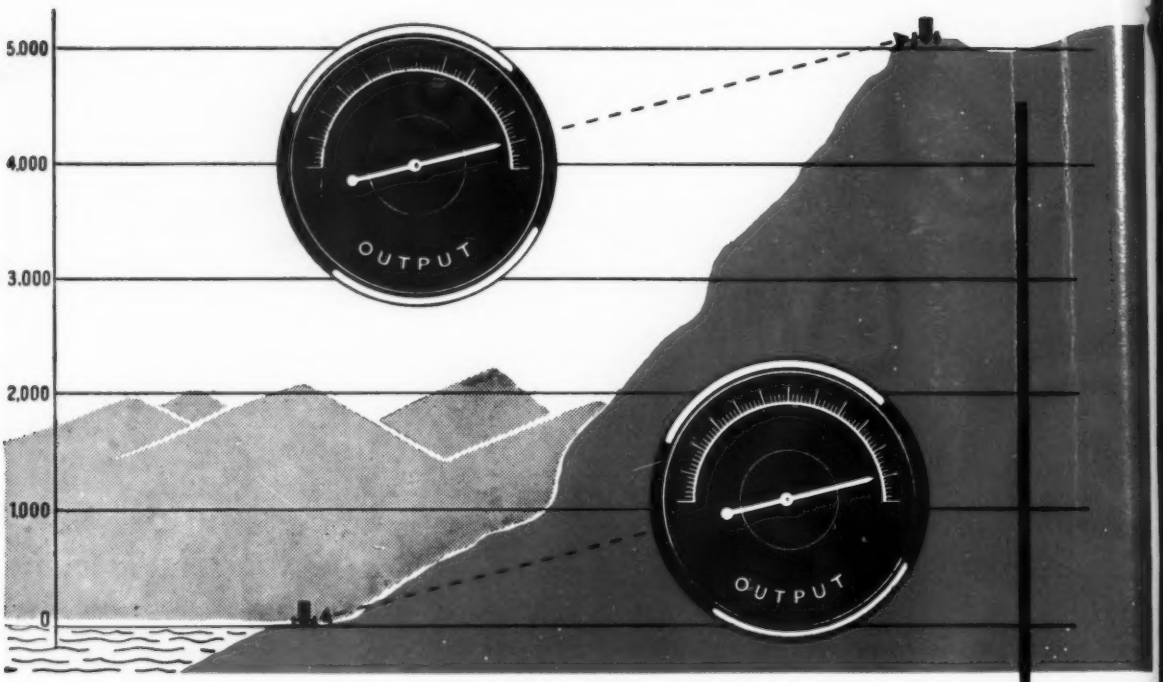
KENT

MASTERS OF INSTRUMENTATION

Factories, Subsidiary Companies and Branch Offices in London, Resolven, Hitchin, Toronto, Montreal, Vancouver, Melbourne, Sydney, Johannesburg, Salisbury, Penang, Bangkok, Brussels, Krefeld, Vienna.

GEORGE KENT LTD · LUTON · BEDFORDSHIRE · ENGLAND

Tick **No 150** on reply card for further details



High output from low power — from sea level to 5000 feet — Holman portable 2-stage compressors

On the seashore or five thousand feet up in the mountains — you'll still get the same high output from a Holman portable compressor. And at low cost, because the maximum volume of air is compressed for a given power. That's one advantage of two-staging. There are others. Temperatures are lower, so a little oil goes a long way — carbon deposits are negligible, valves last longer and overhaul charges are considerably smaller. Friction is cut, too; stresses are reduced and so are the chances of breakdowns.

A Holman portable compressor gives you great operating flexibility and cuts running cost. And it's running cost that is the *real* cost of pneumatic equipment. Get a Holman and you've got the toughest, most efficient and reliable *money-saving* air compressor you'll find.

Hire-purchase terms can be arranged.

Holman PNEUMATIC EQUIPMENT

pays . . . with its life

HOLMAN BROS. LTD., CAMBORNE, ENGLAND
The Holman Organisation is world-wide. It includes the Climax Rock Drill & Engineering Works Ltd., and has agents, branches and technical representatives throughout the United Kingdom and in 84 other countries.
Telephone: Camborne 2275 (10 lines). Telegrams: Airdrill, Telex, Camborne. London Office: 44 Brook Street W.1. Telephone: Hyde Park 9444

H.25